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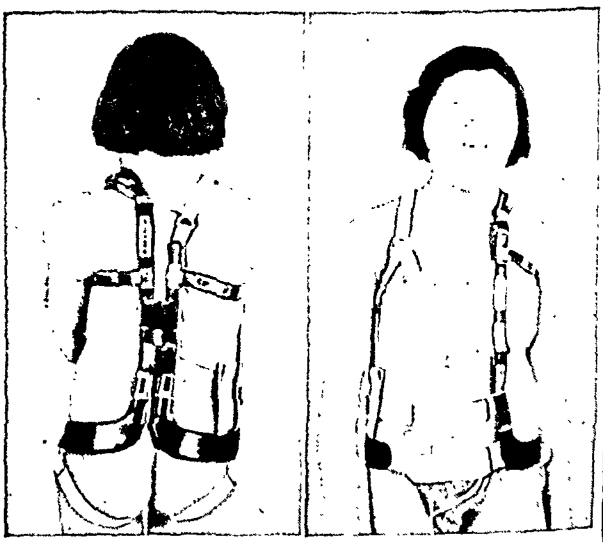

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Transactions of the American Orthopaedic Association

Volume I of *The Journal* (then called the *American Journal of Orthopaedic Surgery*), published in 1903, took the place of Volume XVI of the Transactions of the American Orthopaedic Association. From time to time *The Journal* has requests for copies of the volumes issued prior to that date. Any reader having copies of these earlier volumes, which he is willing to dispose of, is requested to write to *The Journal*, indicating volumes available and selling price.

ADDRESS

THE EDITOR

THE JOURNAL OF BONE AND JOINT SURGERY

8 The Fenway, Boston, Massachusetts

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The Journal of Bone and Joint Surgery

EXPERIMENTAL AND PATHOLOGICAL STUDIES IN THE DEGENERATIVE TYPE OF ARTHRITIS *

BY WALTER BAUER, M.D., AND GRANVILLE A. BENNETT, M.D.,
BOSTON, MASSACHUSETTS

From the Departments of Medicine and Pathology, Harvard Medical School and the Medical Clinic of the Massachusetts General Hospital, Boston, Massachusetts

The term "degenerative arthritis" is employed infrequently by practitioners of medicine as compared with its synonyms "hypertrophic arthritis", "osteo-arthritis", "arthritis deformans", or "senile arthritis". Yet, if one attempts to translate the meaning of the various synonyms for degenerative arthritis or to study in detail the pathology of this type of joint disease, one cannot fail to appreciate that the term "degenerative arthritis" is the most appropriate designation because it portrays very accurately the primary pathological change observed. If the word "degenerative", when used in this connection, describes accurately the primary pathological change, it seems reasonable to conclude that "degenerative arthritis" should be the preferred terminology when speaking of this type of joint disease.

However, one might rightly contend that other intra-articular changes are observed in this type of joint disease. Such a contention is granted, but not without pointing out the fact that such intra-articular findings are secondary to the primary degenerative process. These changes are not only secondary, but usually represent an end stage of this particular pathological state. Translation of the various synonyms reveals that for the most part they refer only to these end-stage findings and not to the primary pathological alteration. For instance, hypertrophic arthritis is defined as a form of arthritis characterized by the hypertrophy of cartilage at the margins of joints, with subsequent ossification of this hypertrophied tissue. In other words, the term when so

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employed refers to the end-stage marginal lipping so frequently demonstrable by roentgenographic examination. This, however, is a late finding and is not demonstrable early in the disease. The term "osteoarthritis" is equally as inappropriate because it implies that the arthritic changes are confined solely to the bony structures. Furthermore, there is no implication as to the nature of the bony changes which will be encountered. The name "arthritis deformans" has been employed by some because marked joint deformity, such as Heberden's nodes, etc., appears late in the disease. Thus the term "arthritis deformans" refers only to the stage of the disease in which gross deformity is readily demonstrated and gives one no inkling as to the nature of the pathological process responsible for such deformity. Furthermore, it must be remembered that other types of arthritis eventually result in gross joint deformity. Of all the synonyms employed for degenerative arthritis, the term "senile arthritis" more nearly portrays the exact pathological state observed. However, one must appreciate that these involutional joint changes are often encountered in younger individuals who display none of the other involutional changes of senility. For this and other reasons, one must realize that there are other causes for such degenerative joint changes than senescence or physiological aging.

If we are to champion "degenerative arthritis" as the preferred terminology for this type of joint disease, we must next consider the evidence that it is primarily a degenerative disease, irrespective of cause. As classical a description of this type of arthritis as exists is that originally presented in the monograph by Nichols and Richardson [7]. Therefore, we present as accurate a summary of their original description of degenerative arthritis as is possible in the space allotted to it.

In degenerative arthritis, the earliest and primary change in the joints is a gradual and uneven degeneration of the hyaline cartilage of the articular surfaces. This is first detected as a fibrillation of the cartilaginous matrix, which generally begins near the articular surface and is associated with a disappearance of the spindle-celled perichondrium. As a result of this fibrillation, which takes place usually at right angles to the articular surface, the neighboring cartilage cells are set free and finally disintegrate and disappear. Also, the original smooth articular surface takes on a papillary appearance. At times this fibrillation is responsible for the freeing of minute masses of cartilage and fibrillated matrix. The depth to which this fibrillation extends varies. Sometimes it extends entirely through the cartilage down to the zone of provisional calcification* so that masses of cartilage may be peeled away, exposing either the zone of provisional calcification or the underlying bone to the attrition of joint motion. Occasionally, only a portion of the articular cartilage undergoes degeneration, fibrillation, and destruction. This leads to thinning of the

* We reserve the term "zone of provisional calcification" for the deepest layer of [cart]ilage in growing bone. We prefer the term "calcified cartilage" for that layer of [cartil]age referred to by Nichols and Richardson as the "zone of provisional calcification".

cartilage over a circumscribed area. To meet this erosion and depression, an overgrowth occurs on the opposite joint surface. This is brought about by increased activity of the perichondrium. As a result, an irregular or somewhat toothed joint line is formed and, finally, with ultimate disappearance of the entire articular cartilage, the two bony surfaces are brought into contact. Since this change takes place gradually and is at first confined only to a portion of the joint, motion is continued with the result that the exposed bone undergoes marked thickening of the trabeculae and narrowing of the marrow spaces until an extremely dense bony structure has been produced. The friction of continued joint motion produces a high degree of polish on the exposed condensed bone which then acquires an appearance closely resembling ivory; hence the term "eburnation of bone".

While this process of fibrillation and destruction of cartilage with erosion is taking place in one portion of the joint and a corresponding overgrowth is occurring on the opposite joint surface, secondary changes in the joint may be produced. Changes in the shape of the joint surface may gradually, over a period of months or years, lead to more or less extensive subluxations. As a result, the amount of joint motion may be diminished or, in certain instances, the joint surfaces may become interlocked, producing "ankylosis by deformity". There is no true ankylosis in this type of joint disease. Common among these imperfectly understood secondary changes is an increased activity of the perichondrium at the periphery of the joint where the cartilage and capsule come together. This results in the new formation of cartilage which may be transformed into bone and thus causes an increase in the size of the bone end. As a rule this increase in circumference is not uniform, but is irregular and the contour is nodular, as exemplified by Heberden's node. Since this deposit of new bone is usually within the attachment of the joint capsule, it may in some cases lead to filling up of the original joint cavity, thus producing partial or complete dislocation.

As a rule, no great increase in the thickness of the joint capsules of these joints is observed, and, in many instances, the synovial membrane appears normal. However, in some cases, there is marked thickening of the synovial membrane with the production of papillary or pedunculated masses of connective tissue which may be converted by metaplasia into cartilage or bone or, in some cases, into fat tissue. Detachment of these pedunculated masses may give rise to loose bodies, the so called joint mice. The breaking off of an osteophyte is another cause of loose-body formation. As a rule, in this type of joint disease there is very little tendency for the synovial membrane to extend over the articular surfaces and in no case does fibrous ankylosis occur.

Nichols and Richardson in their monograph also call attention to the fact that in the early degenerative changes in the articular surfaces the is no evidence of inflammatory exudation.

Having presented the evidence of Nichols and Richardson that

type of arthritis represents a true degenerative process, we can next inquire as to what factors are responsible for the maintenance and nutrition of normal articular cartilage and its ability to regenerate.

In order to evaluate the importance of apposition and weight-bearing, the following experiment was undertaken: Dogs' knee joints were disarticulated. The patellae and patellar ligaments were utilized in covering the denuded femoral articular ends. In each case, by careful closure of the synovial membrane and joint capsule, a fairly satisfactory sac, lined with synovia and enveloping the end of the femur, was obtained. These dogs were sacrificed twelve and twenty-eight weeks later. The femoral articular ends were very similar in appearance. Fine and coarse adhesions separated the space lined with synovia into numerous compartments containing synovial fluid. The articular cartilage was dull gray in color and showed numerous areas of partial atrophy and degeneration. Gross sections revealed marked atrophy of the subchondral bone. Microscopic examination corroborated this finding. The articular cartilage was greatly thinned out, showing depressed areas in which complete degeneration had occurred. The calcified zone of cartilage was reduced in thickness. In some sections, the articular cartilage was covered by a thin layer of fibroblasts which had originated at the perichondrial border. These findings suggest that apposition and weight-bearing of adjoining articular surfaces are of importance in the maintenance of normal articular cartilage.

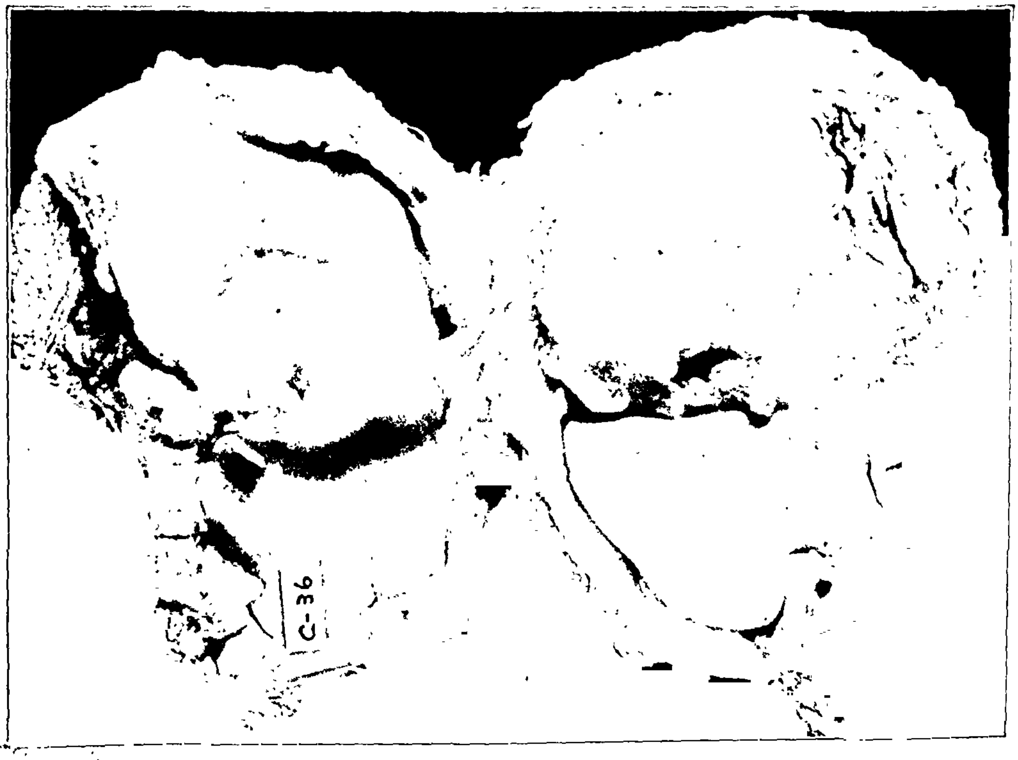


FIG. 1

Photograph (three-quarters natural size) of the opened carpometacarpal joint of a young beef steer, showing moderately well advanced degenerative lesions in the opposing articular surfaces of the medial condyle.

FIG. 2

Photomicrograph (× 65) of one of the earliest degenerative lesions observed in the carpometacarpal joints of cattle. The articular cartilage shows early fibrillation and splitting of the matrix, distortion of the columns of cells, and cellular proliferation near the articular surface. The calcified zone of cartilage directly beneath the surface lesion is depressed, thinned out, and completely disrupted in several areas.

The nutrition of cartilage must play an equally important rôle in the maintenance of normal cartilage and its ability to regenerate. The cartilage at the perichondrial margins probably receives its nourishment from the circulus articuli vasculosus of Hunter. As has been shown [3], it is in this region that articular cartilage shows the greatest ability to repair itself. The central portion of the articular cartilage is avascular and the exact source of its nourishment is unknown. It may be that it is derived solely from synovial fluid, or from serum water diffusing through from the subchondral-bone vessels, or a combination of the two. The ability of the central portion of articular cartilage to repair itself is at best very feeble and limited [3]. Reasoning teleologically, one might argue that this restricted source of nourishment is adequate explanation of the fact that articular cartilage is a tissue with a low metabolic rate. One might also reason *a priori* that with a limited nourishment, especially in the case of a specialized tissue such as articular cartilage in which the matrix is in great excess as compared to the cellular elements, the ability of cartilage to regenerate would at best be very feeble.

That such a state of affairs is true is readily demonstrated by two types of experimental study: (1) a systematic study of degenerative articular-cartilage lesions, occurring spontaneously in bovine joints [2]; and, (2) a study of the repair of surgically created articular-cartilage defects in dogs [3].

In all cattle over two years of age, there occurred regularly an artic-

lar-cartilage defect on the opposing articular surfaces of the medial side of the metacarpal and carpal bones (Fig. 1). The earliest of these articular-cartilage defects were characterized by slightly depressed roughened areas which occurred in the concave surface of the medial articular cartilage. Microscopically, the earliest change noted was thinning of the layer of calcified cartilage. The roughened areas proved to be distorted and scattered groups of cartilage cells covered by fibroblasts. Associated with these changes there were frequently noted varying degrees of fibrillation of the cartilage matrix and distortion of the columns of cartilage cells (Fig. 2). In the slightly more advanced lesions, shallow depressions and definite thinning of the articular cartilage had occurred. In such instances, the calcified zone was markedly thinned, disrupted, or absent. The larger and deeper areas of degeneration in articular cartilage were sharply outlined by an irregular margin of overhanging cartilage (Fig. 3). The base of such defects extended into subchondral bone. Microscopic examination of such lesions revealed that the articular cartilage had completely disappeared in this sharply demarcated area of degeneration. Subchondral bone had disappeared in some instances for a depth six times the thickness of articular cartilage. At the margins of *these defects, there occurred an abrupt change from normal hyaline*

Fig. 3

Photomicrograph (× 76), showing the abrupt overhanging margin of a fully developed degenerative lesion in the articular surface of the carpal bone. Fibrous tissue lining the defect has extended only a short distance on the adjacent articular cartilage and there is little evidence of reparative activity. No noteworthy evidence of inflammation was observed in this joint.

FIG. 4

Photomicrograph (× 95) of a shallow and incompletely developed defect in the carpometacarpal joint of a young steer. The calcified zone of cartilage is broken in many places, thus permitting fibrous tissue to grow through from the subchondral-bone spaces and to line the base of the defect. Such fibrous tissue is converted into fibrocartilage or finally, in some instances, into atypical hyaline cartilage. This lesion showed evidence of more active reparative changes than were observed in any other lesion studied.

cartilage into fibrocartilage and fibrous tissue. The bases of the defects were lined by avascular fibrous tissue. This fibrous tissue was occasionally replaced by fat tissue. The underlying bone trabeculae showed evidence of atrophy and rearrangement; in one instance, definite crushing of the trabeculae was observed. The marrow spaces were filled with fat, but showed no evidence of fibrous-tissue proliferation. These lesions did not necessarily progress once they had developed. No important pathology was found in the synovial membranes of such joints. Such cartilage defects were not associated with other joint changes, nor were they the cause of such changes. What we wish to stress most of all is the fact that there never was more than minimal evidence of cartilage repair in any of these lesions (Fig. 4).

It is our belief that these progressive articular-cartilage defects are due to the repeated traumatization of the weakly constructed carpometacarpal articulations in an area where the underlying subchondral bone does not adequately support the articular cartilage. Such trauma to the metacarpal joint occurs each time the cow lies down or gets on to her feet from the recumbent position.

In order to study further the ability of articular cartilage to regenerate, surgically created defects on the weight-bearing portion of the femoral condyles and in the central portion of the patellar grooves of the knee joints of dogs were studied at intervals varying from four to twenty-eight weeks after such defects were made [3]. In certain instances, these defects

were made sufficiently deep to extend into the underlying subchondral bone.

The results of such experiments may be briefly summarized as follows:

1. In a few instances, no evidence of any type of cartilage repair was demonstrable.

2. Repair may take place by independent proliferation of original cartilage cells. Such proliferative activity of cartilage cells is greater in the deeper zones of articular cartilage. More active proliferation of cartilage cells is observed in lesions made on the weight-bearing surface of the femoral condyle or in lesions in which crevices exist, suggesting that the friction generated by movement of the patella over such defects may be inhibitory to repair in this manner. In no instance was repair complete at the end of twenty-eight weeks. In the majority of instances, the repairing tissue filled but a small portion of the defect crater.

3. Repair may take place by proliferation of vascular connective tissue from the perichondrial margins. In such instances, the vascular connective tissue invades the defect, and may pass through the stages of fibrous tissue, fibrocartilage, and an imperfect hyaline cartilage.

4. Repair of the defects which have extended into the subchondral bone proceeds in an orderly sequence. First there occurs an ingrowth of vascular connective tissue from the bone-marrow spaces, which subsequently becomes fibrocartilage and finally an imperfect hyaline cartilage. In this type of defect, one observes the most rapid and constant type of repair of the articular-cartilage crater. These later findings suggest that any denuded areas of articular cartilage, particularly the type of defect encountered in osteochondritis dissecans, might be expected to regenerate with this type of imperfect hyaline cartilage if, at the time of operation, the margins of the defect were shaved down to viable cartilage and if free communication with the underlying subchondral-bone spaces was established.

5. Comparative studies indicate that the repair of such surgically created defects in similar areas in the joint is no more rapid or complete in young puppies before closure of the epiphysis than it is in adult dogs.[6]

6. The presence of such surgical defects was not a cause of other important joint pathology.

7. The repair of articular cartilage is at best very feeble. Therefore, it would seem justifiable to conclude that, once cartilage destruction or degeneration has occurred, there is very little chance that any appreciable degree of repair will ever take place. This being the case, we can scarcely expect to cure this type of arthritis. The best we can hope for is to remove if possible all accelerating factors, such as obesity, displaced patellae, faulty mechanics, unusual use, or trauma, etc., to which the joint is constantly being subjected and thereby to arrest or slow up the process of wear and tear or degeneration.

At the time of operation on the knee joints of the dogs, displacement

of the patella was necessary in each case in order to create the surgical defect on the weight-bearing portion of the femoral condyle. Evidently this undue stretching of the patellar ligaments in such instances was the cause of the permanent patellar displacement observed postoperatively in a few of the dogs. Such displacement was toward the medial side of the joint so that the patella was in apposition with the medial epicondylar ridge of the femur. This anatomical derangement invariably caused marked intra-articular pathology, whereas, in the joints in which the patellae remained in their normal positions, such changes were not observed.[3]

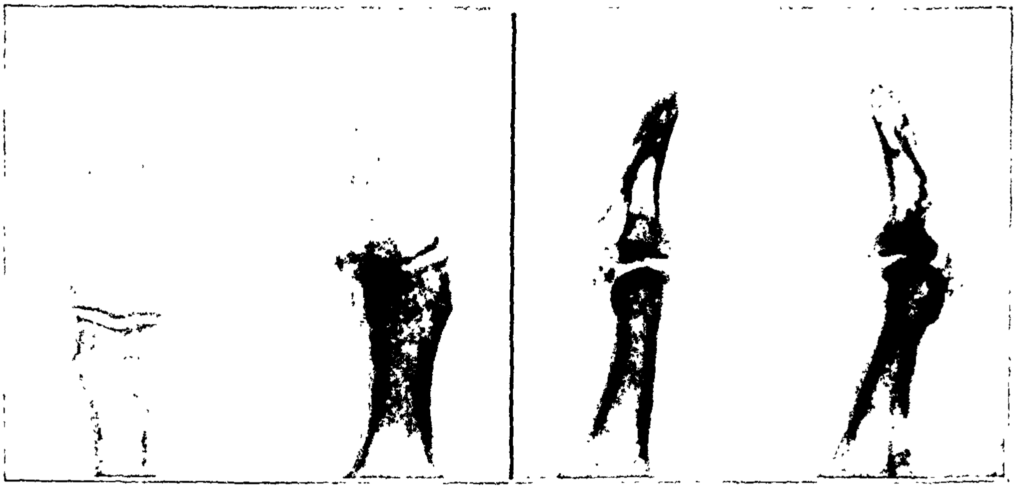
The changes noted were similar to those of degenerative arthritis in man. The patellar cartilage showed varying degrees of atrophy and degeneration. In one instance, there was almost complete degeneration of the cartilage, with roughening and fragmentation of the underlying bone. On the inner side of the medial patellar ridge, where the patella had rested, there were areas of cartilage degeneration and atrophy. On the opposite patellar condyle, it was noted that marginal proliferation of the cartilage had occurred. In such instances, the margins were raised, scalloped, and nodular. Numerous blood vessels had grown in from the adjoining synovial membrane. Thus, the proliferative and degenerative changes in articular cartilage, together with subchondral-bone overgrowth similar to that seen in degenerative arthritis, had seemingly resulted in these joints from simple patellar displacement.

Because of these observations, further studies concerning the effects of patellar displacement were undertaken.[5] These experiments were carried out on rabbits in which the desired derangement can be produced without opening the joint space or otherwise injuring any of the joint structures. Gross and microscopic examination of these joints revealed that anatomical changes, similar to those of degenerative arthritis, occurred as early as four weeks after displacement of the patella. These changes progressed and became more marked in the experiments of longer duration. Marked lipping of the articular margins of the femur occurred. This was accompanied by degeneration of the original articular-cartilage surfaces and, in some instances, by eburnation of the denuded bone.

Evidence is also obtainable from the clinic which readily demonstrates that extensive intra-articular changes, indistinguishable from degenerative arthritis, occur at a much earlier age in individuals with displaced patellae. This anatomical derangement in older individuals is the cause of unusually extensive intra-articular changes of the degenerative type.

In a study[1, 4] designed to obtain an accurate visual picture, as well as a description of supposedly normal joints at various ages, we collected : series of knee joints from normal individuals who in so far as we coul determine had never had symptoms of joint disease. These joints we obtained at necropsy. At least six knee joints, representing each deca from the first to the tenth, were collected. These joints were st

roentgenographically, macroscopically, and microscopically. Such studies revealed that, with each succeeding decade in life beyond the second, the knee joint shows increasing pathological changes, degenerative in nature and confined for the most part to the articular surfaces. Often such changes are not demonstrable by x-ray examination. Arteriosclerosis does not appear to be an important etiological agent. The synovial membrane in such joints was either normal or showed only minimal changes. In such joints, there is little or no evidence of attempted repair. The earliest as well as the most advanced changes observed in these joints were identical in kind and indistinguishable from those commonly spoken of as characteristic of degenerative arthritis. From these studies, it is obvious that an individual may have extensive



Left Right Left Right

FIG. 5

Anteroposterior and lateral roentgenograms of the left and right thumbs of a seamstress who had worked for many years as a cutter. The constant and long-continued cutting with scissors resulted in a typical Heberden's node on the right thumb. These changes were minimal or absent in the left thumb and other phalangeal joints.

degenerative joint disease without having important symptoms referable to the joints. It is equally as apparent that roentgenographic examination usually does not give an accurate idea as to the extent of the intra-articular changes in this type of joint disease. If such extensive pathological changes can be demonstrated in individuals who deny having had joint symptoms, it is obvious that the surgeon should be very familiar with the appearance of joint structures at various ages, if he is to interpret properly the intra-articular changes which he encounters at the time of operation.

Since these changes were observed in the knee joints of individuals who supposedly never had had joint symptoms or joint disease, it seems [illegible]ical to conclude that they represent the changes which result from [illegible]ly use and increasing age.

Because of these findings, we undertook to determine what changes [illegible]t take place in human joints subjected to unusual use or repeated

trauma. In such cases, the joint which had been subjected to constant use or unusual trauma was compared with the opposite joint which served as the normal control. For instance, a woman who had worked as a cutter in a tailoring establishment for fifteen years had a prominent Heberden's node on the thumb of the hand which was used in cutting, but no such nodosities were demonstrated on any of the other fingers (Fig. 5). Roentgenograms of another patient revealed extensive degenerative arthritic changes with loose-body formation in the right knee, whereas the left knee showed very minimal changes (Figs. 6 and 7). From her history, it was learned that this patient had operated a treadle machine for thirty years. In so doing, she was required to flex and extend her right knee hundreds of times each day, thereby subjecting this joint to unusual use for thirty years. Extensive changes, indistinguishable from advanced degenerative arthritis, were found when the knee was operated upon. Other patients demonstrated similar changes in joints which had been subjected to unusual trauma or excessive use.

From these observations, it would seem that one is justified in concluding that unusual use and repeated trauma are of themselves adequate causes for the production of extensive degenerative arthritic changes.

From these studies, it is apparent that extensive degenerative joint changes can take place as a result of the wear and tear of long continued daily use and increasing age, displaced patellae, unusual use, and repeated trauma. The changes resulting from these factors are evidently more marked in the case of articular cartilage than in other body tissues because of the limited ability of articular cartilage to regenerate. From clinical observations, we further appreciate that these changes can also be produced or, if present, hastened by increasing the load which the joint has to carry or by impairing the normal mechanics of the joint (Figs. 8 and 9). Such additional factors include obesity, knock knees, bow legs, fracture into the joint, poor alignment following fractures, severe pronation of the feet, etc. If such factors have been operative for a long time, evidence of degenerative joint changes will appear long before senescence has set in. In all probability, the type of cartilage that one inherits also governs in part, not only the age of onset of such joint changes, but also the rapidity with which such changes take place. Certainly there is no reason to doubt that the type of cartilage present must vary considerably from individual to individual. One might argue that there may be certain accelerating factors which could conceivably injure or impair articular cartilage and thus be responsible for the earlier development of such joint changes in certain individuals. All one can say in answer to such an argument is that to date there is no proof of the existence of such factors.

From the studies concerning the degenerative articular-cartilage lesions which occur spontaneously in bovine joints and the repair cartilage in surgically created joint defects, it is apparent that the ability of articular cartilage to repair itself is at best feeble. Furthermore, little evidence of attempted repair was observed in the human joints show

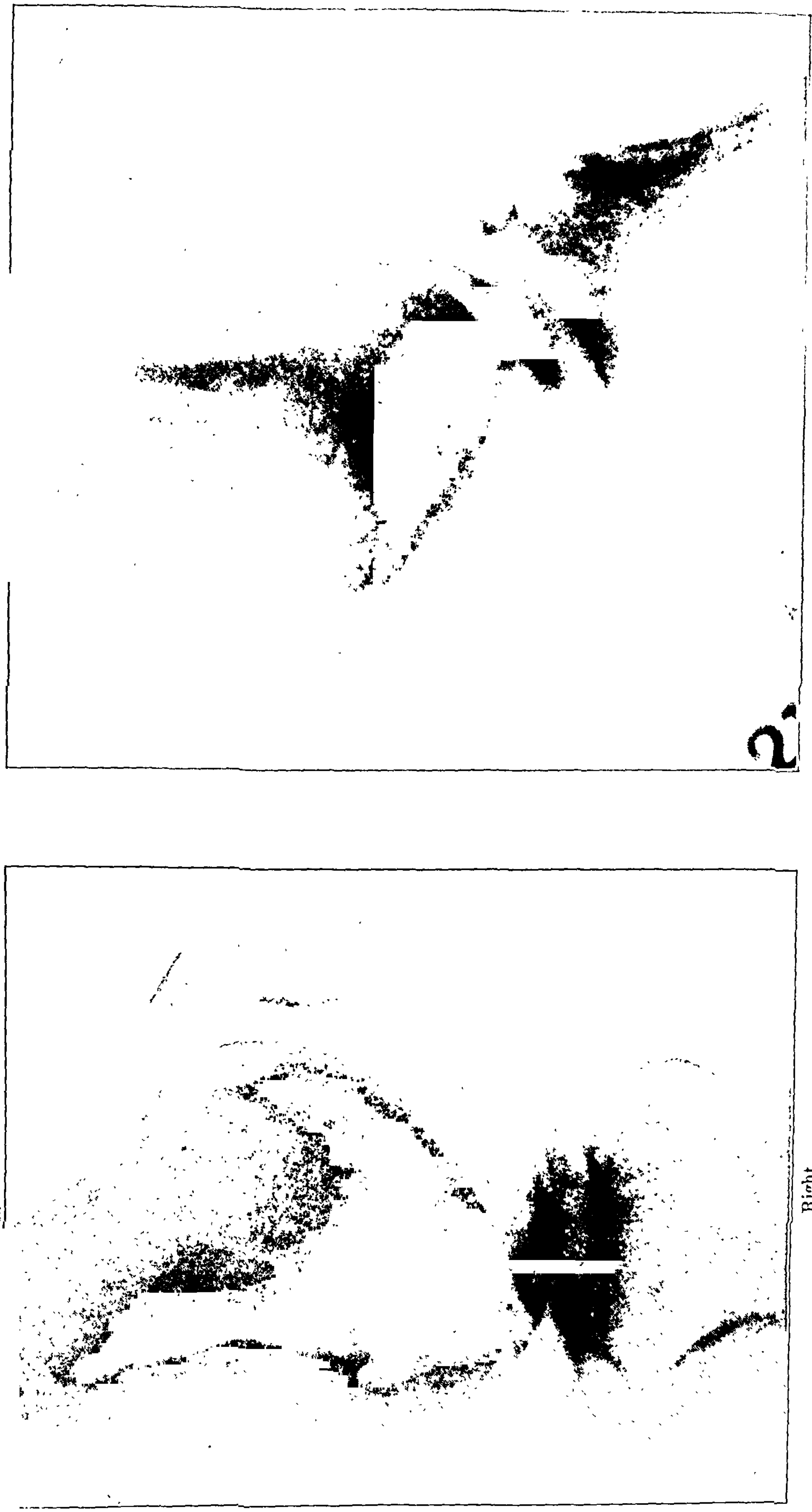


FIG. 6

Lateral roentgenograms of the right and left knee joints of a patient forty-seven years old. (See Fig. 7.)

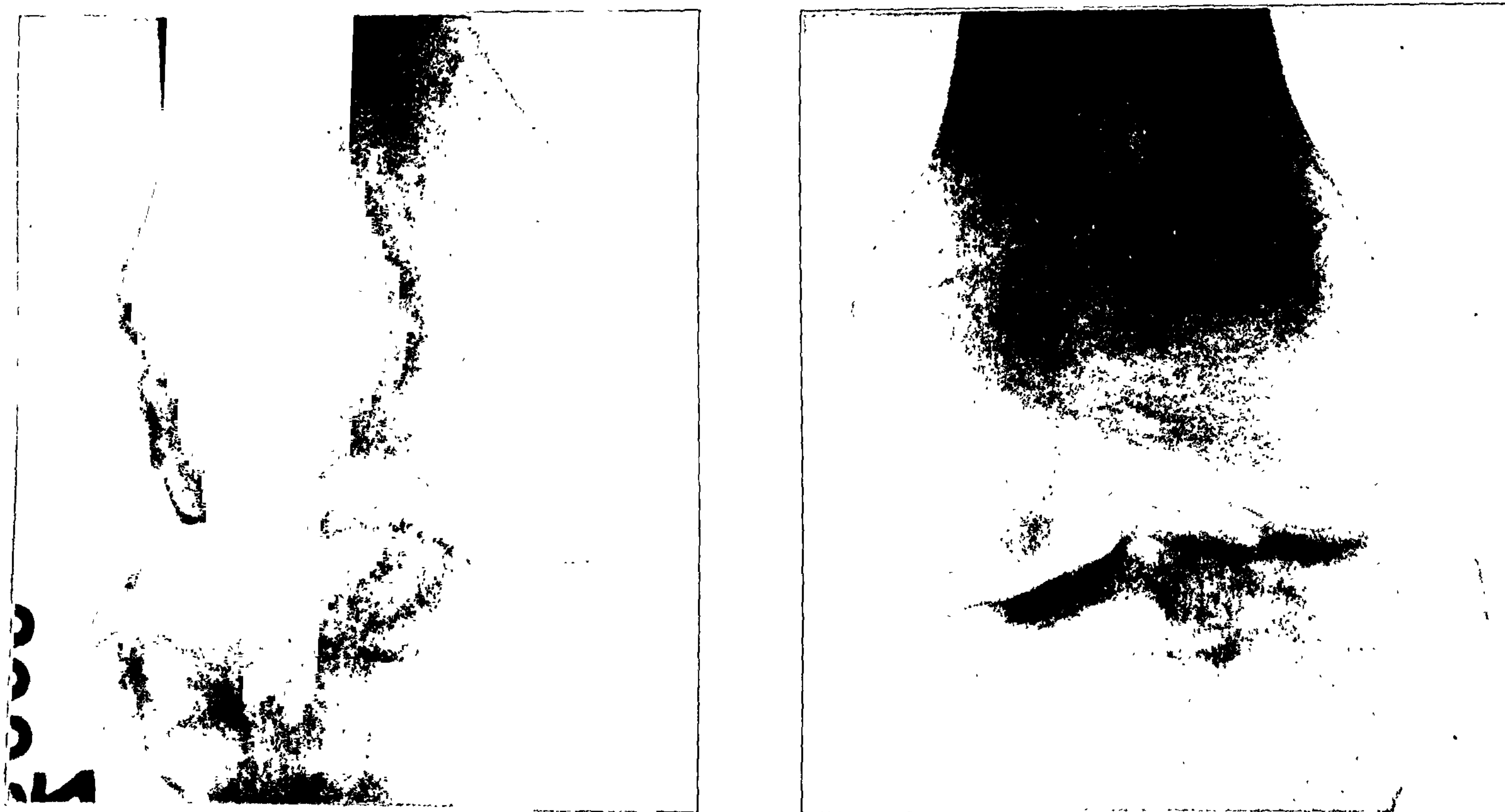


Fig. 7

Anteroposterior roentgenograms of same patient as shown in Fig. 6. This woman had operated a punching machine in a shoe factory for thirty years. Her work had necessitated the intermittent flexion and extension of the right knee in displacing a foot treadle. The roentgenograms demonstrate marked hypertrophic changes and loose bodies in the right knee joint, whereas the left knee joint shows no more changes than one would expect to find in a woman of this age. At operation there was observed wide-spread degeneration of the articular surface of the patella and patellar surface of the femur with marginal lipping. Two loose bodies were removed.

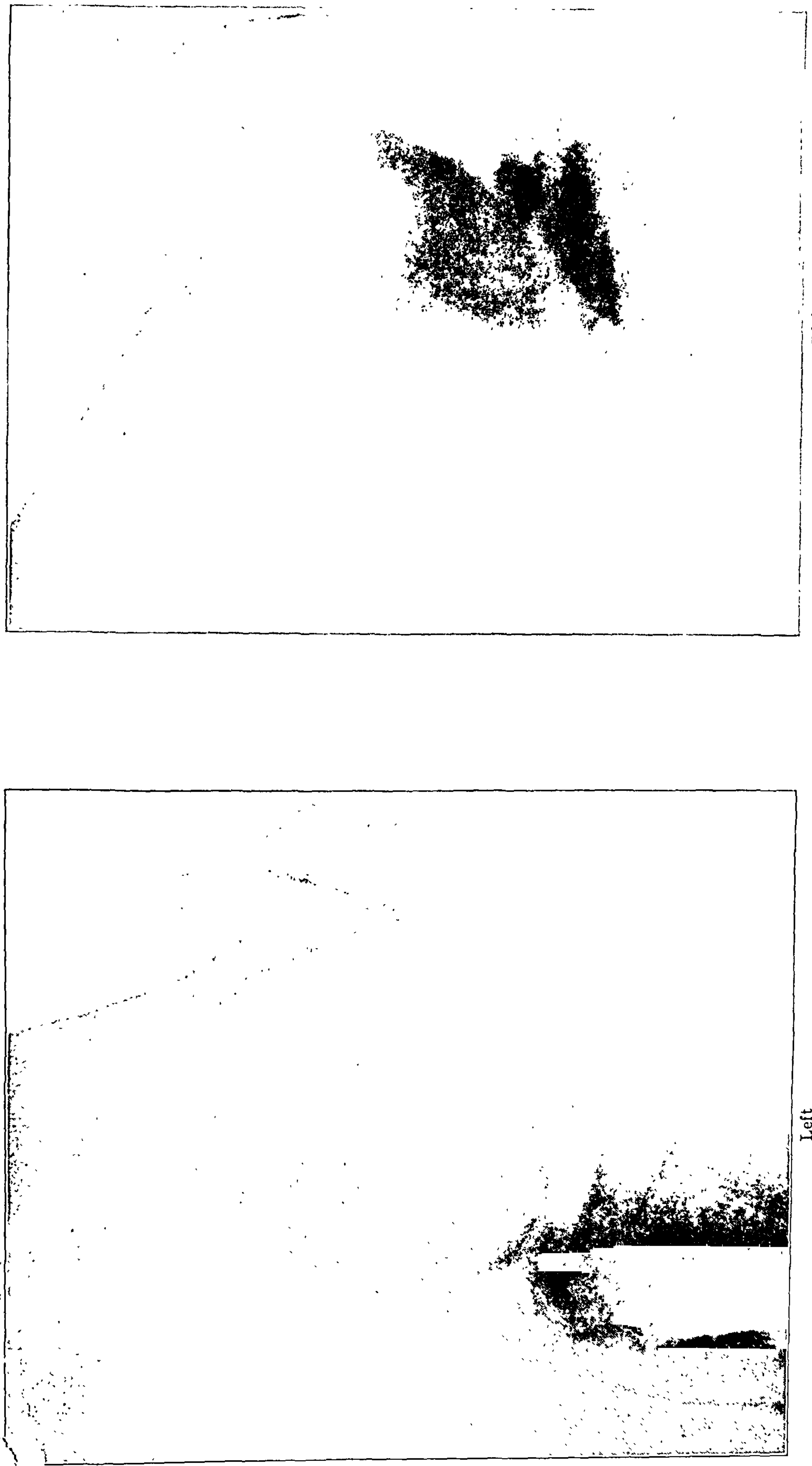
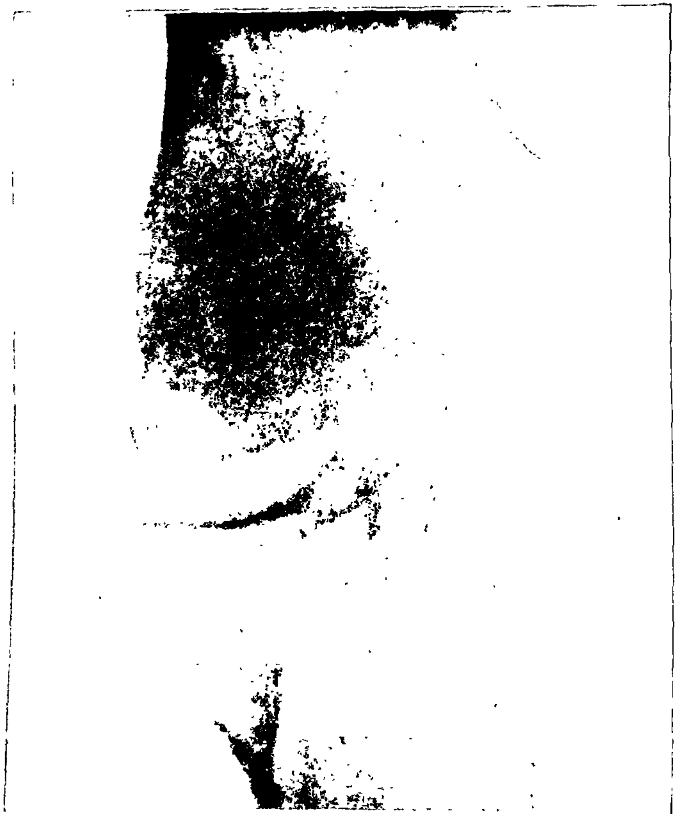
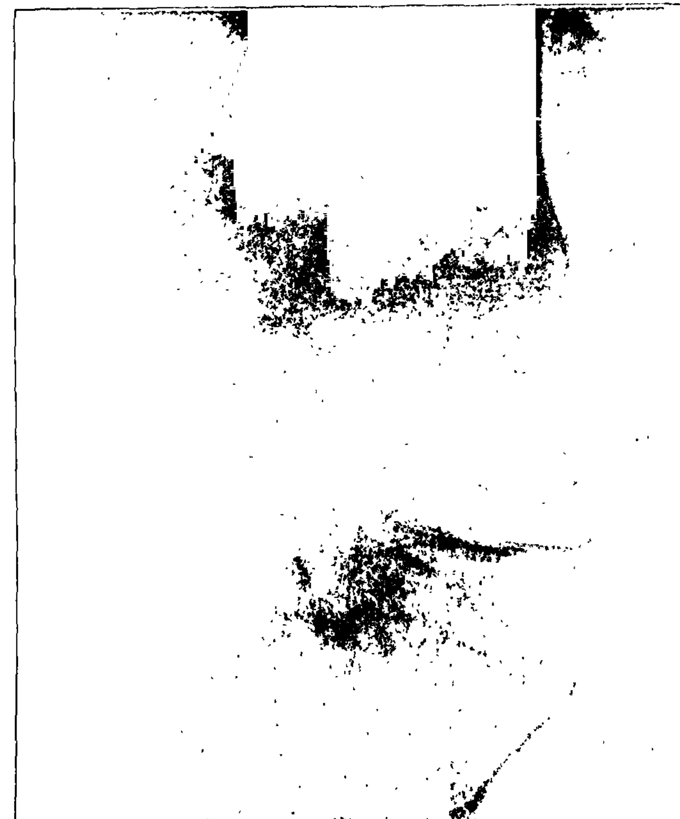


FIG. 8

Lateral roentgenograms of the left and right knee joints of a woman fifty years of age. (See Fig. 9.)



Left



Right

Fig. 9

Anteroposterior roentgenograms of same patient as in Fig. 8. Very marked hypertrophic and degenerative changes are shown. There is evident marked lipping of the patellae, femora, and tibiae, as well as loose bodies in both knees. The loose bodies in the right knee were removed at operation. At that time it was noted that the articular surfaces showed advanced degenerative changes, including eburnation of bone. These excessive joint changes are attributed to long-standing obesity and genu valgum.

extensive degenerative changes. Thus it would seem fair to assume that little can be accomplished in the way of curing this type of joint lesion. However, if any causative or accentuating factor present can be corrected or done away with, it seems reasonable to believe that the process may be arrested or its rate of progress slowed up considerably.

The one point which we wish to stress is that in this type of joint disease the primary pathological change is one of degeneration, all other changes being secondary to the primary process. If such is the case, it seems reasonable to conclude that we should retain the word "degenerative" in this connection in preference to any of the other synonyms which are so frequently employed. This one word "degenerative" describes with great exactness the joint changes which occur and, therefore, if employed regularly to designate this type of joint disease, it would automatically portray the joint in question. In this same connection, one might rightly challenge the use of the word "arthritis" when speaking of this type of joint disease, because there is little or no evidence of inflammation in any of the structures of such joints. Some workers have suggested the term "osteo-arthrosis" for this type of joint disease. The name "osteo-arthrosis" seems a poor substitute for the previously employed terminology because, if literally translated, it means a joint full of bone. For the reasons previously given, we personally would prefer to speak of this type of joint change as the degenerative type of joint disease.

Similar degenerative joint changes are encountered in hemophilia*, gout, and Charcot's joint. In Charcot's joint, whether secondary to tabes dorsalis, syringomyelia, or leprosy, all the previously described changes are much more marked.

Because of the simultaneous existence of the degenerative type of joint disease and rheumatoid arthritis in the same individual, some workers have interpreted such findings as meaning that both diseases are due to infection. We cannot subscribe to this unitarian etiological theory. The intra-articular changes in these two diseases are in no way similar. It is true that an individual with degenerative joint changes may at some subsequent time develop rheumatoid arthritis. In such a case, the joint so affected will show on examination the degenerative changes as well as the inflammatory changes associated with rheumatoid arthritis. Similarly, rheumatoid arthritis with the characteristic periarticular swelling of the midphalangeal joints (spindle fingers) may develop in a person exhibiting Heberden's nodes and thus the telltale evidence of both diseases may be present. However, one must remember that evidence of inflammatory change is absent in an uncomplicated case of degenerative joint disease. Furthermore, rheumatoid arthritis may cause sufficient joint destruction so that the joint is no longer mechanically normal or stable. In consequence, the joint is subjected to increased trauma, as well as to wear and tear, and, as a result, degenerative joint changes ensue. How-

* We recognize the fact that the degenerative cartilage changes seen in hemophilic joints are only one phase of the entire pathological process.

ever, the examples just cited are not proof of the unitarian theory; they merely represent the existence of two diseases in the same individual.

If we are to interpret this type of joint disease as primarily a degenerative process, what bearing does this have on the symptomatology, prognosis, and treatment? At the time when the marginal-tissue proliferation is taking place, the periosteum may become elevated and, in consequence, pain may result. Once this proliferation of the marginal osteoid tissue ceases and this tissue becomes calcified, pain may no longer be present. Therefore, any treatment employed may be given credit for beneficial results, whereas the improvement may well be due to the natural evolution of such joint changes. This certainly is often the case with Heberden's nodes because they are frequently tender and painful in the earliest stages and later become quiescent. The other causes of pain in such joints are the altered mechanics and, occasionally, loose-body formation, or the impingement of a pedunculated synovial-membrane villus. In such instances surgery offers the only hope of alleviation of symptoms.

The most important feature of this disease as it concerns the patient is that he can be assured that he will never become a crippled invalid. Joint deformities, subluxations, and restricted motion do occur but such joints never go on to ankylosis.

In the treatment of this disease, we should all remember that it is primarily a degenerative disease, caused by the wear and tear of increasing age, unusual use, repeated trauma, faulty mechanics, loss of pain sensation, etc. There is no evidence favoring the various infectious, metabolic, or endocrine theories. Therefore, these patients should not be subjected to wholesale removal of foci, endless sera and vaccines, endocrine therapy, colonic irrigations, hyperpyrexia, weird dietary regimens, etc. True, a low-caloric diet will often result in sufficient weight reduction to bring about painless knees. However, in such instances, the weight reduction is the all-important factor and not any one special dietary feature. Weight reduction, if indicated, correction of faulty mechanics, and reassurance are the most important features in treating this disease. These patients must be reassured that they are not headed for crippledom and a life of invalidism.

CONCLUSIONS

1. We are of the opinion that degenerative arthritis is the result of the wear and tear of increasing age and repeated trauma which may be caused in a variety of ways and that it is not the result of an inflammatory process, metabolic disturbance, or endocrine dysfunction. The type of cartilage inherited may be responsible for the earlier onset and more extensive changes encountered in one individual as compared to another.

2. Because of the inability of articular cartilage to regenerate, we are of the opinion that one cannot cure this type of joint disease. Certain measures, however, can be instituted which will either arrest or slow the progress of the degenerative process.

3. Extensive degenerative joint change can be present in an individual without necessarily causing important joint symptoms.

4. If hypertrophic or degenerative arthritis is nothing more than degenerative joint changes due to the wear and tear of increasing age, unusual use, or repeated trauma, one has the right to challenge the correctness of the use of the word "arthritis" with reference to individuals with such joint changes. We, therefore, propose the name "degenerative joint disease" for this type of joint pathology.

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STREPTOCOCCIC DISSOCIATION IN THE PATHOGENESIS OF CHRONIC RHEUMATOID ARTHRITIS*

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Our earlier experimental work[7,8] demonstrated that the arthritic lesions produced in rabbits by mannite-fermenting streptococci were of striking similarity to the characteristic rheumatoid involvement in the human. The experimentally produced lesions were more acute at the onset, but, when this initial phase had subsided, the subsequent course was practically identical in both types of lesions.

Assuming these experimentally produced lesions to be pathologically identical with the naturally acquired human type, the crux of the test of streptococcic culpability seemed to rest on the possibility of demonstrating bacteria in human arthritic lesions with reasonable uniformity and regularity. We felt that the paucity of uniformly positive findings in biopsy material was due either to the actual absence of organisms or to the presence of growth-checking properties of joint and tissue fluids. Stained sections of affected joints were almost uniformly negative for bacteria. When cultured, rheumatic and arthritic nodules and lymph glands adjacent to joints gave more definite results in the hands of a number of investigators; and joint scrapings gave irregularly positive cultures that were considered inconclusive because of the relative inconstancy of the findings.**

For the past four years, the New York Orthopaedic Hospital and several other institutions have furnished us with biopsy material obtained from twenty-one joint operations on an equal number of patients. These cases were representative of the various types of more or less chronic arthritic lesions. Despite the fact that this number is admittedly too small for the forming of definite conclusions, we feel that certain aspects of our comparative clinical, pathological, and bacteriological studies on these cases are sufficiently interesting to warrant this preliminary report.

Clinically, the majority of the cases included in this study were diagnosed preoperatively as chronic proliferative arthritis in which the disease was more or less inactive, and surgery was resorted to in an attempt to restore at least part of the normal function of the joint through the removal of excessive synovial proliferation, freeing of the joint cavity from loose bodies, or relieving pain by curetting exostoses.

A careful survey of the histories revealed the fact that, during the more active phase of the disease, these patients had suffered either from rheumatoid-arthritis in its pure form or from the type in which bone

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** Among these investigators are: Rosenow; Richards; Forkner, Shands, and Poston; Key; Cecil, Nicholls, and Stainsby; Poston; Margolis and Dorsey; Dawson, Olmstead, and Boots; and Gray, Fendrick, and Gowen.

change complicates the picture and exostoses form in addition to synovial proliferation. Because of the comparative inactivity of many of these lesions at the time of operation, and also on account of the rather misleading previous histories obtained, we felt that the best basis for classification could be evolved from a study of the activity of the arthritic processes as revealed by pathological sections rather than from the present clinical history. The criteria for determining activity were the degree of tissue reaction in terms of granulation, vascularization, perivascular infiltration, and histology of infiltrating and proliferating cells. *Completely inactive, slightly active, moderately active, and highly active forms could thus be clearly differentiated.*

TABLE I

CLINICAL, PATHOLOGICAL, AND BACTERIOLOGICAL ANALYSIS OF TWENTY-ONE CASES OF OPERATIVE

	Clinical and Pathological Grouping of Material	Bacteriological Findings * — Diphtheroid Bacilli: *Ordinary Pleomorphic*	Bacteriological Findings * — Micrococcus: *Albus Aureus*	Micrococcus: *Tetragenus Sarcina*	Streptococcus: *Viridans Hemolyticus*	Pathological Findings ** — Connective Tissue: *Hyaline*	Connective Tissue: *Fibrotic*	Connective Tissue: *Loose*	Synovial Tissue: *Proliferation*	Synovial Tissue: *Villous Processes*	Cell Infiltr[ation]: *Polynuclear*	Cell Infiltr[ation]: *Mononuclear*
	GROUP I Inactive forms of:											
E.	Chronic atrophic hypertrophic	– –	– –	– –	– –	+ + +	+ +	+	+	+ +	–	
U.	Chronic atrophic hypertrophic	– –	– –	– –	– –	–	+ + + +	–	–	–	–	
	GROUP II Slightly active forms of:											
O.	Chronic atrophic hypertrophic	**+** –	– –	– –	– –	+	+ + +	–	–	+	–	
R.	Chronic atrophic proliferative	**+** –	– –	– –	– –	–	+ + + +	–	–	–	–	
	GROUP III Moderately active forms of:											
E.	Chronic atrophic proliferative	**+** –	**+** –	– –	– –	–	+ + + +	–	–	+	–	
E.	Chronic atrophic proliferative	– **+**	+ –	– –	– –	+	+ + +	+ +	+	+	–	+
C.	Chronic atrophic proliferative	+ –	– **+**	– –	– –	+	+ + +	+ +	+ +	+ + +	–	+
L.	Chronic atrophic proliferative	+ **+**	**+** +	– –	– –	–	+ + +	+	+ +	+ +	+ +	
A.	Chronic atrophic hypertrophic	– –	**+** –	– –	– –	–	+ + + +	–	–	+	–	
N.	Chronic atrophic hypertrophic	– –	**+** –	– –	– –	–	+ + + +	–	–	–	–	
A.	Chronic atrophic traumatic	– –	**+** –	– –	– –	–	+ + +	+ +	+	+	–	
O.	Chronic atrophic traumatic	– –	**+** –	– –	– –	–	+ + + +	+	+	+	–	
A.	Chronic atrophic traumatic	– –	**+** –	– –	– –	–	+ + + +	+	+	+	–	
U.	Chronic atrophic traumatic	– –	**+** –	– –	– –	–	+ +	+ + +	+ +	+ +	–	+
R.	Chronic atrophic proliferative	– –	**+** –	– –	– –	+ +	+ +	+ + +	+ + +	+ +	+	+
	GROUP IV Active forms of:											
E.	Chronic tuberc. proliferative											
D.	Chronic atrophic proliferative	– –	– –	– –	**+** –	+ + +	+ + +	+ + +	+ + +	+ + + +	–	+ + + +
[illegible]	Chronic atrophic proliferative	– –	– –	– –	**+** –	–	+ +	+ + + +	+ + + +	+ + + +	–	+ + + +
[illegible]	Chronic atrophic degenerative	– –	– –	– –	– **+**	–	–	+ + + +	+ + + +	+ + + +	+ +	+ + + +
	GROUP V Subacute form of:											
. C.	*Tenosynovitis of the digital tendons*	+ –	– –	**+ +**	– –	No tissue pathology						
	GROUP VI *Acute form of:*											
. C.	Exudative metastatic arthritis	+ +	+ +	+ +	+ **+**	No tissue pathology						

* The bold face plus signs indicate the originally isolated micro-organism. The subcultural findings are denoted by the light plus signs.
** The degree of cellular reaction is indicated by the number of plus signs: + slight, + + + + very marked, etc. The minus sign indicate[s] [illegible] issue [illegible].

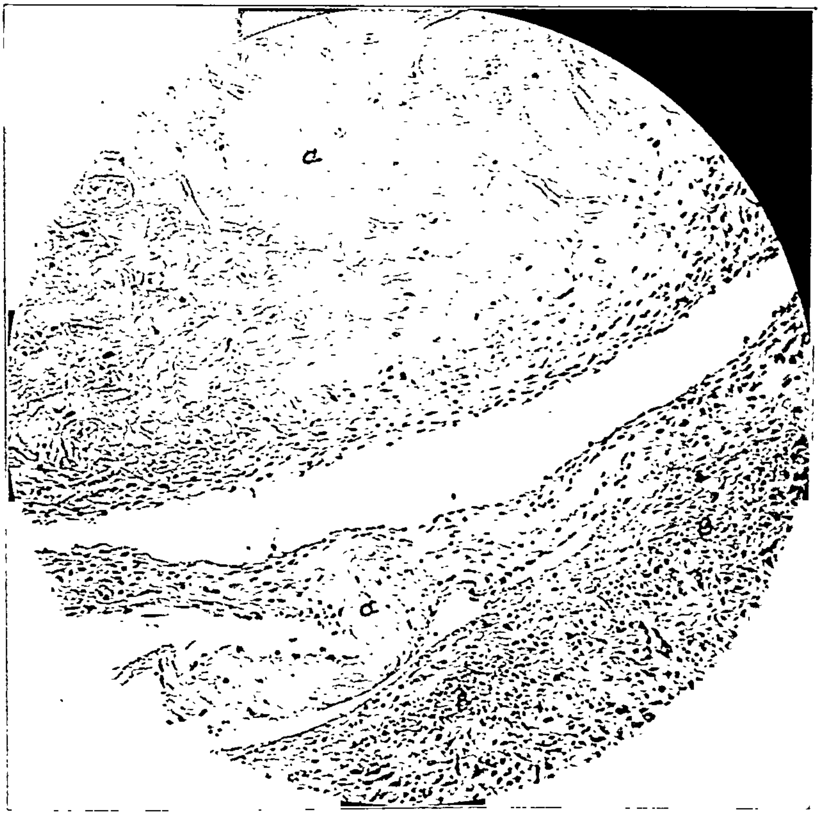

FIG. 1

Case 10. B. E. Hematoxylin-eosin stain (× 160).
Pathological features of an inactive, "residual" arthritis as classified in the table under Group I, showing:
a: Progressive hyalinization of the connective tissues of synovia and villus processes.
b: Remains of old lymphocytic infiltration in the sclerotic connective tissue of synovia.

In addition to the chronic arthritides, we were able to study one case of subacute tenosynovitis of the phalangeal extensor tendons and one case of acute metastatic arthritis of the elbow complicating a mastoiditis. Classification thus based on tissue reactivity showed an enlightening comparison between the activity of the process and the bacteriological findings (Table I).

Using our previously described technique for tissue culture[5], we found that avascular tissues were invariably negative bacteriologically. Cartilage and bony or villous fragments, loose in the joint cavity as rice bodies, were uniformly sterile. Since the growth and propagation of micro-organisms depend on the constant replenishment of nutrient material, tissue with a terminal blood supply—such as the vascularized synovia, the bone marrow, and the haversian system—should be the best suited for positive cultures. Such was found to be the case in the human as well as in the rabbit.

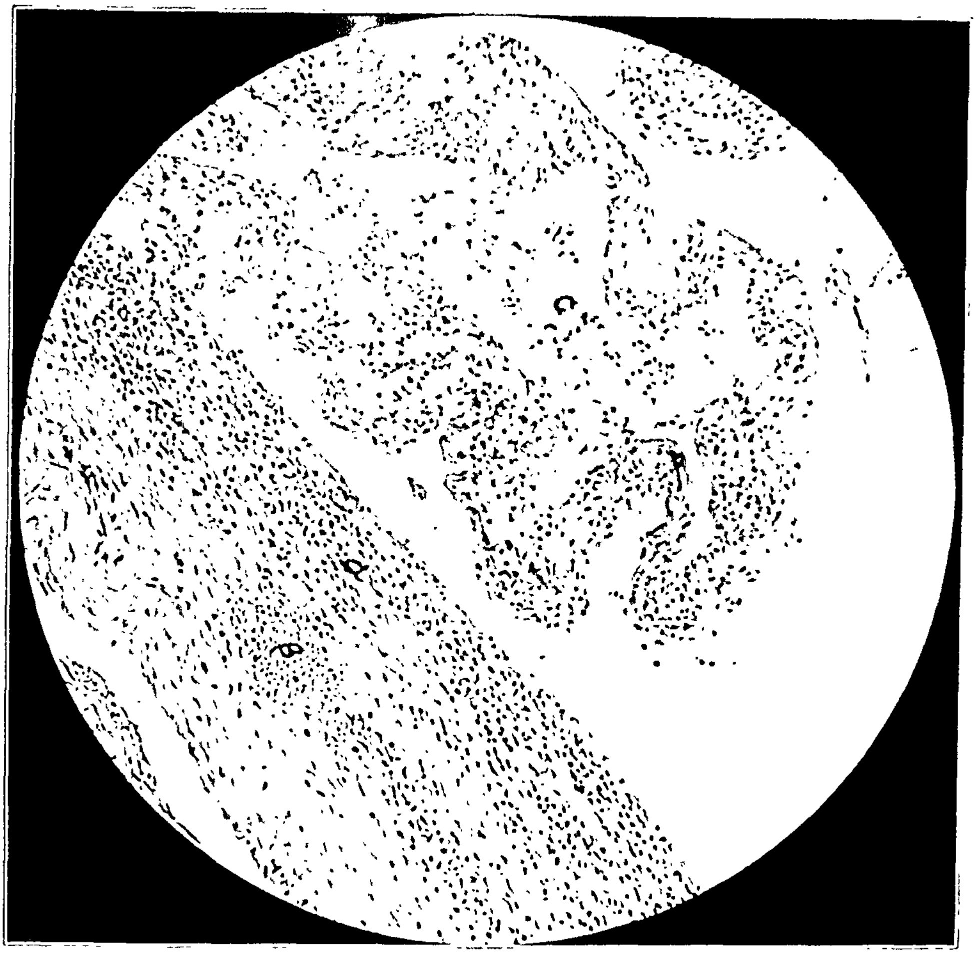

FIG. 2

Case 4. U. L. Hematoxylin-eosin stain (× 160).
Pathological features of a moderately active case as classified in the table under Group III, showing:
a: Low-grade cellular activity of the connective tissue of synovia.
b: Small collections of lymphocytic infiltration.
c: Moderately sized villus processes with the same degree of cellular activity.

The bacteriological, pathological, and clinical findings are given in Table I. The cases are grouped in series according to the activity of the arthritic process.

GROUPS I AND II

These four cases represent almost, if not completely, inactive forms of "residual" arthritis which, due to the passage of time, previous treatment, or natural immunity, has become quiescent with only residual manifestations of a mechanical nature for which the patients have sought relief. Two patients (Cases 9 and 10) were operated on for the removal of loose bodies in the joint cavity (the knee) and the other two patients (Cases 8 and 18) had curettage of spurs and exostoses.

Pathologically, the synovia was either completely fibrotic or partly degenerated into hyaline tissue. Occasionally, slight connective-tissue proliferation of the synovial membrane could be noticed, but there was no evidence of lymphocytic or plasma-cell infiltration. Figure 1 (Case 10) is

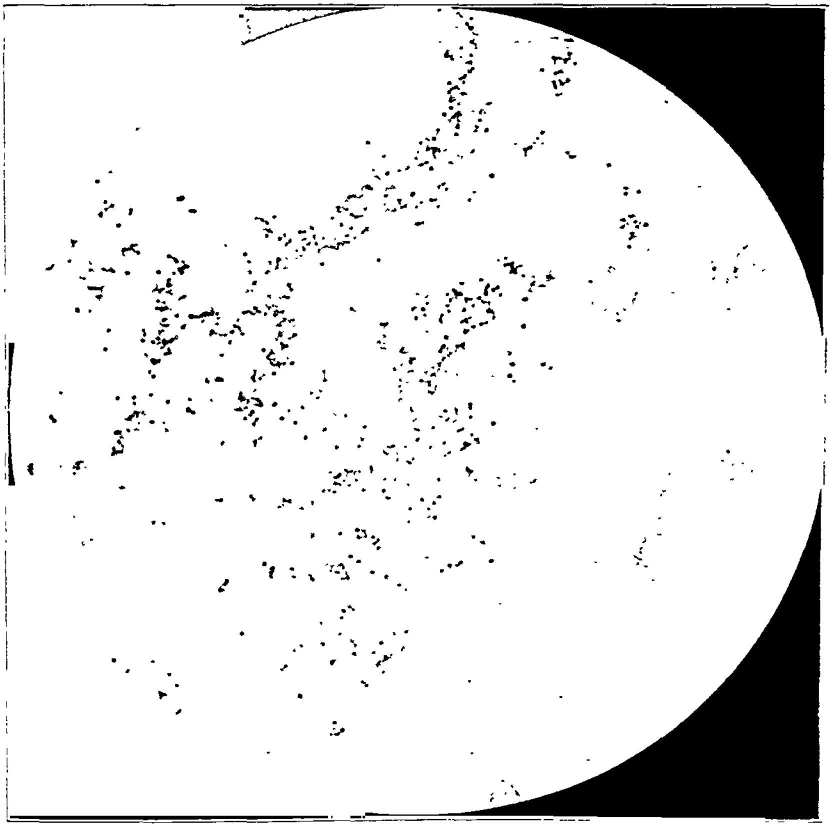

FIG. 3

Case 16. B. R. Gram stain (× 900).
Demonstration of staphylococci in synovia by the tissue-culture method.

representative of this group. Bacteriologically, the tissues either were sterile (Cases 10 and 18) or showed diphtheroid bacilli (Cases 8 and 9).

GROUP III

This group, which represents the moderately active phase of chronic proliferative arthritis, clinically, at least, is not homogeneous. A careful survey based on anamnesis would subdivide it into three groups. In Cases 4, 5, 16, and 19, the patients were chronic arthritics in whom the disease had been at a stage of quiescence similar to that of the preceding two groups, but their symptomatology had been intensified by trauma such as a blow, fall, or similar injury which had caused an exacerbation of pain or disability. Surgical intervention was justified as a corrective means for symptomatic relief. In Cases 1, 5, 17, and 21, torn internal semilunar cartilages were removed for the same reason, and in Cases 1, 3, 6, and 7, redundant synovial tissues had to be eliminated to restore part of the function of the joint. In the majority of these cases operations were performed on either one or both knees to overcome mechanical interference with function, while other joints such as wrists and ankles were

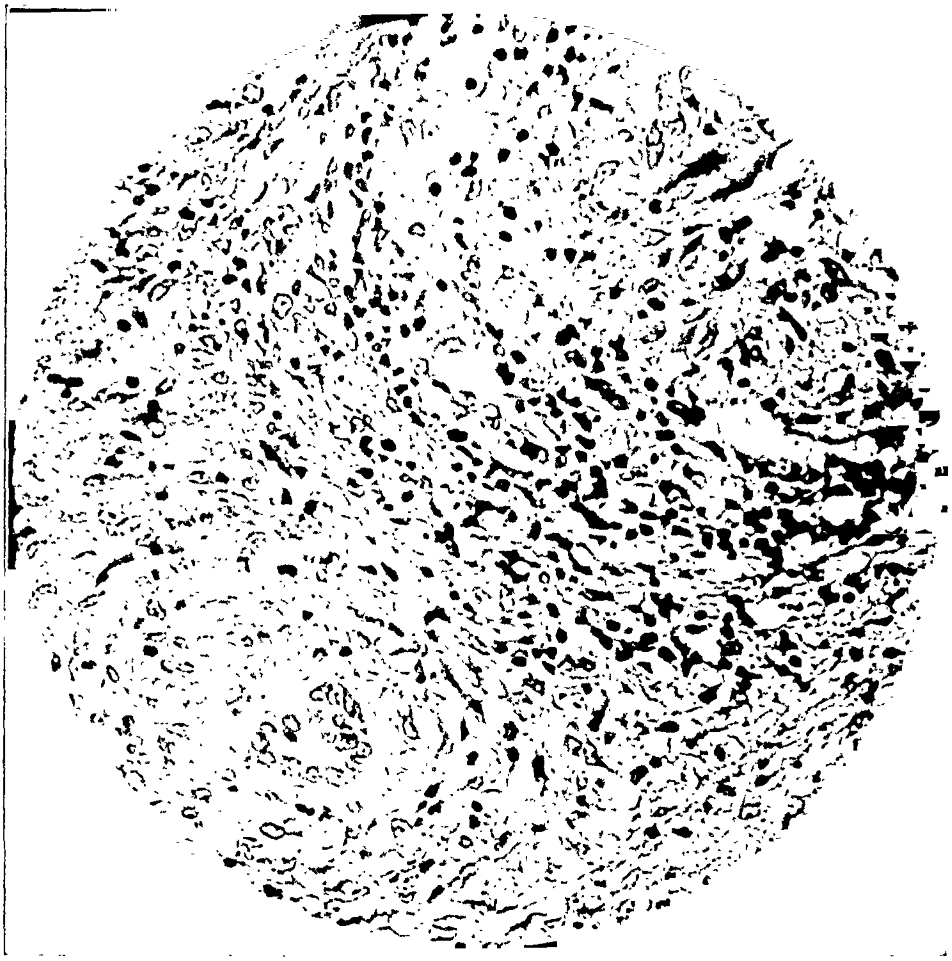

FIG. 4

Case 13. V. E. Hematoxylin-eosin stain (× 320).
A case of chronic tuberculosis of the knee joint with typical giant-cell formation.

quiescent or inactive. This particular group of patients had been afflicted for an average of three years by a true rheumatoid arthritis with superimposed villous overgrowths and exostoses, necessitating operative interference. This condition was demonstrated particularly well in Cases 1, 3, 6, and 7.

With slight variations in each case, the pathological picture was that of a chronic, low-grade, exudative-proliferative process. It was characterized by moderate thickening of the synovia, the formation of villous processes, and low-grade proliferation of these processes with young connective-tissue cells. The synovial parenchyma was moderately vascularized and slightly infiltrated with lymphocytic cells. In the main, this infiltration was diffuse, but occasionally it appeared to be perivascular. Plasma-cell infiltration, on the whole, was absent except in two cases (Cases 3 and 16), and, in these, it was not in any way an outstanding feature. Figure 2 (Case 4) is representative of this group.

Bacteriologically, in seven of a total of eleven cases, we grew micrococci similar to the staphylococcus albus. In the remaining four, there was a mixed staphylococcoid and diphtheroid growth. Although clini-

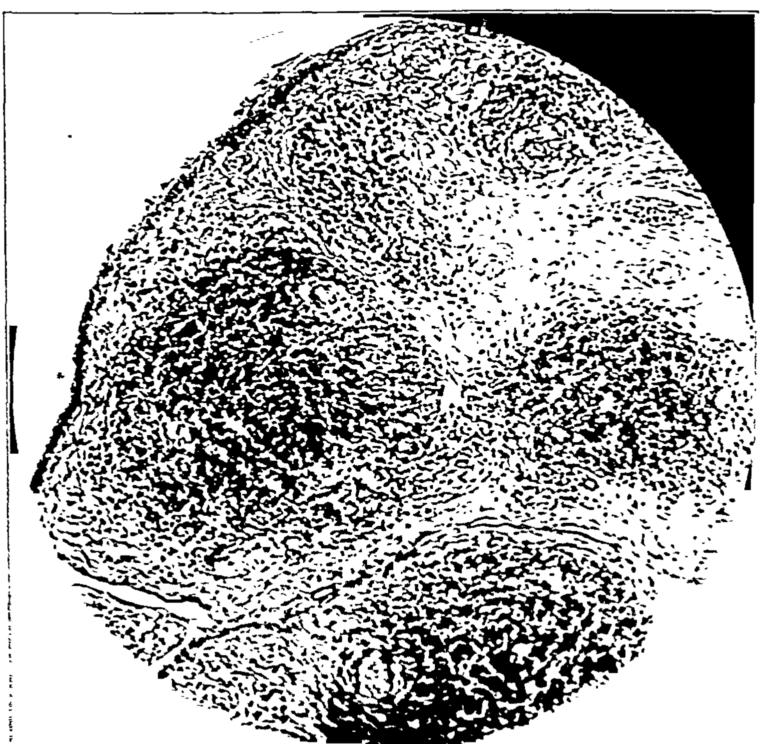

Fig. 5-A

Case 14. T. S. Hematoxylin-eosin stain (× 150).
Pathological features of an active form of arthritis as classified in the table under Group IV, showing actively proliferating and highly vascularized synovial tissues, infiltrated profusely with mononuclear cells.

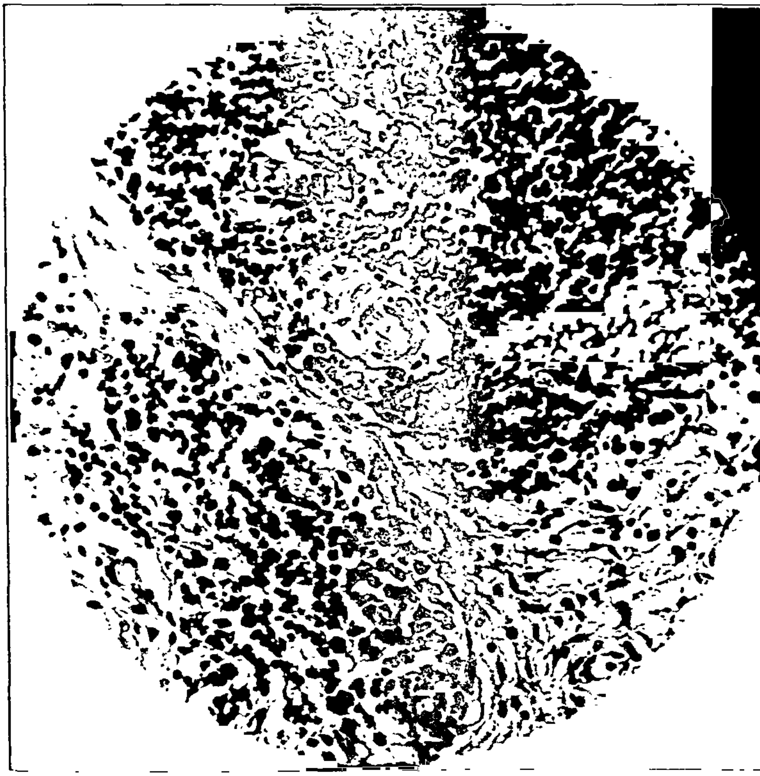

Fig. 5-B

Case 14. T. S. Hematoxylin-eosin stain (× 300).
This is a higher magnification of Fig. 5-A to bring out the histology of cellular infiltration. Note the perivascular distribution of lymphocytic cells and the activity of plasma cells in the synovial parenchyma. Note also the marked degree of endarterial proliferation of the intimal layer.

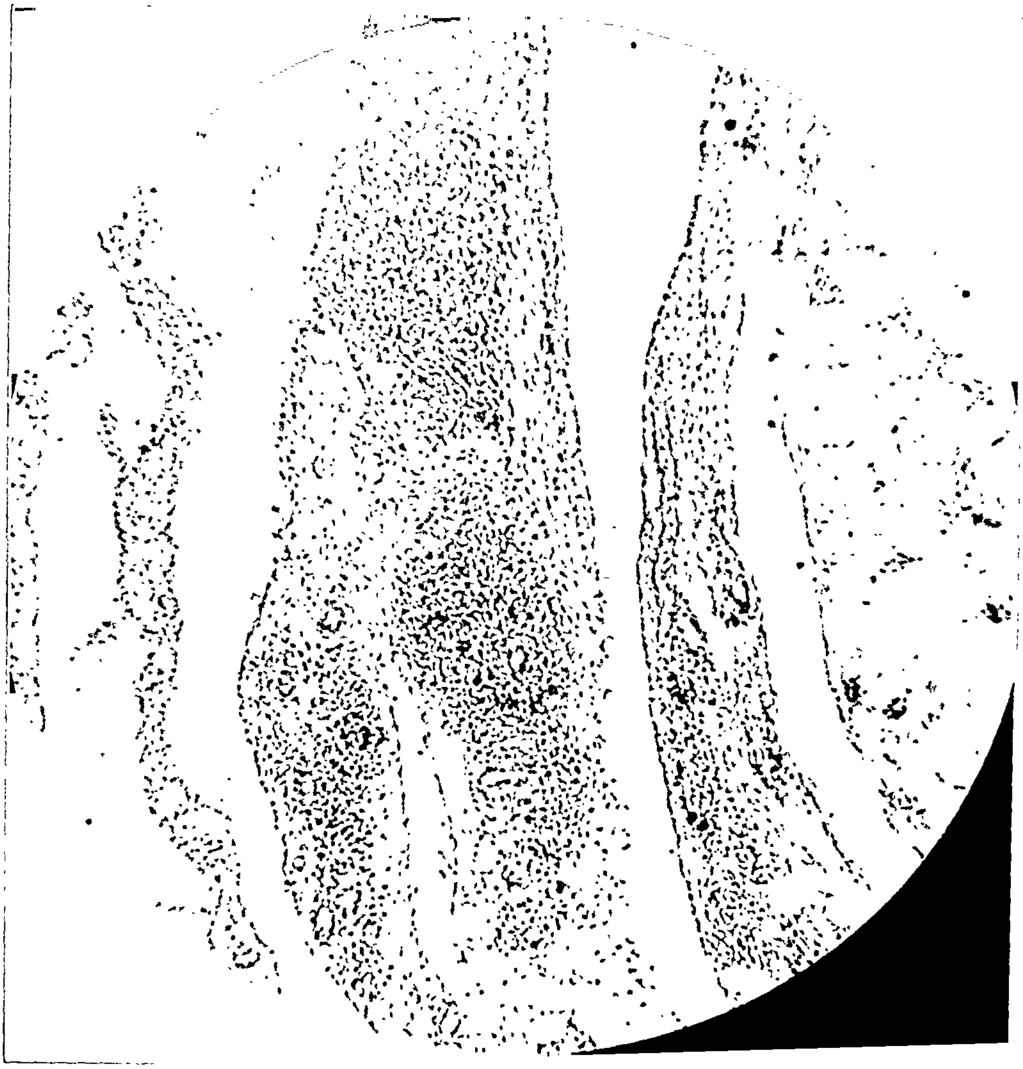

FIG. 6

Case 20. E. D. Hematoxylin-eosin stain (× 180).
Another active case belonging to Group IV, showing extensive villus overgrowths, marked vascularization, and perivascular lymphocytic infiltration.

cally all eleven cases were grouped together as moderately active, the mixed bacterial types (Cases 4, 5, 6, and 15) could be differentiated pathologically by the absence of plasma-cell infiltration. Whether or not this was a chance occurrence it is difficult to decide definitely, as the number of cases is inadequate. However, in view of the relatively simple pathology of the diphtheroid-positive group (Group II), the fact that this group was the closest approach to the culturally sterile group (Group I), and also in consideration of the fact that we found the diphtheroid phase to be the last in the course of an infection, as will be developed later, we feel that it is more than a mere coincidence. Figure 3 (Case 16) is a demonstration of staphylococcic forms in the synovial tissue.

GROUP IV

Of the four cases classified as active forms of chronic rheumatoid arthritis associated with marked proliferative changes, Case 13 did not

properly belong to this study, for, although originally diagnosed as chronic proliferative arthritis of unknown etiology, postoperative pathological studies disclosed its tuberculous origin (Fig. 4). However, such an analogy with cases of rheumatoid arthritis was shown as to warrant its inclusion. The remaining three cases could be very easily differentiated from the preceding groups by the intense lymphocyte and plasma-cell infiltration of the loose connective synovial-tissue network, which was highly vascularized and crowded with villous processes. The synovial capillaries, although mostly patent, had been narrowed considerably by definite proliferation of the intimal layer. These changes can be seen in the photomicrographs, Figures 5-A, 5-B, and 6.

The bacteriology of this group was similar to our previous cultural findings in the experimental arthritis of rabbits,—namely, mannite-fermenting streptococci: a streptococcus viridans in Cases 2 and 20 and a streptococcus hemolyticus in Case 14. In Case 13, the tissue from the tuberculous knee was sterile, as would naturally be expected. Figures 7-A and 7-B demonstrate the distribution of streptococci in the synovial tissue.

Before we take up the subacute and acute forms of arthritis (Cases 11 and 12), we will discuss these seemingly unrelated bacteriological findings in chronic arthritic tissues and their bearing on the bacteriology of the acute forms.

DISCUSSION OF BACTERIOLOGICAL FINDINGS

When we commenced this particular investigation four years ago, we were guided by our success in uniformly demonstrating streptococci in the cultured joint tissues of rabbits in which typical rheumatoid arthritis had been produced by the intravenous injection of arthrotropic streptococci isolated from the blood stream of human chronic arthritics. Our experience with human arthritic tissues seemed very discouraging, for, out of a total of nineteen more or less chronic arthritic tissues which were cultured, only three were positive for streptococci; the remainder either were sterile or showed only staphylococcoid forms and diphtheroid bacilli.

The negative cultural results in totally inactive forms of arthritis, such as the first group of cases, were not at all unexpected, but the appearance of diphtheroid bacilli in the slightly active forms and staphylococci, either alone or in association with diphtheroid bacilli, in the moderately active forms could not easily be accounted for. Should we consider them as contaminations when every possible precaution was taken to eliminate this source of infection? Or, assuming that they were tissue-invading organisms, should we attribute to them pathological significance?

We felt that they were not contaminations, but, for reasons easily understood, it was difficult to control this work with normal joint tissue of human origin. Nevertheless, we had the opportunity of culturing th digital joints of three stillborn babies and the biopsy material obtaine from two bone punctures for blood-dyscrasia studies. In all five ca the tissues cultured were sterile. Our experience with the joint tissue

Fig. 7-A

Case 2. Y. O. Gram stain (× 1,280).
Demonstration of diplococci with the typical morphology of streptococcus faecalis in synovial tissue by the tissue-culture method.

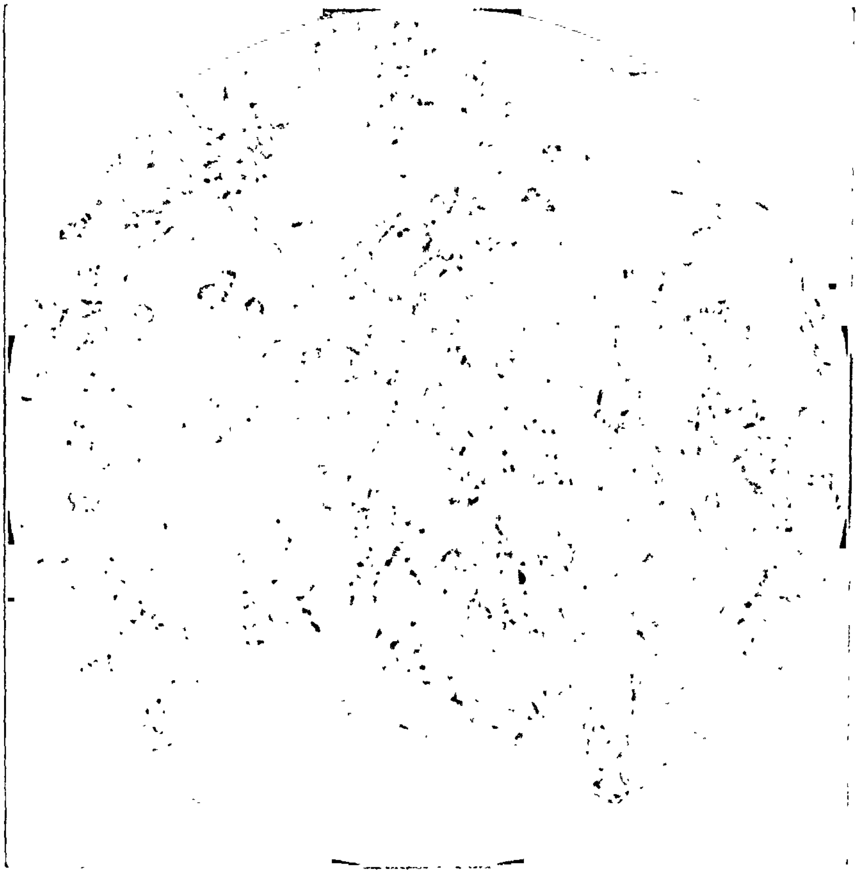

Fig. 7-B

Case 2. Y. O. Gram stain (× 800).
Same as Fig. 7-A, showing streptococci in ordinary chains.

from normal animals, which we have examined in sufficient numbers, has been that, with due precaution of asepsis, such tissues were invariably sterile.

To determine whether the non-streptococcic findings had any pathogenic potentialities, we injected these cultures into rabbits. All diphtheroid forms and the majority of staphylococcic forms could be given in massive doses without eliciting any pathology. Some of the staphylococcic forms were mildy pathogenic, but in no instance could we discover an arthrotropic selectivity such as was the case with mannite-fermenting streptococci. We noticed, however, that normal rabbits injected with such diphtheroid organisms became highly susceptible to arthritic lesions from subsequent injections of arthrotropic mannite-fermenting streptococci (streptococcus infrequens).

GROUPS V AND VI

In the following two cases of acute arthritis we had what seemed to be a clue to unravel through the labyrinth of the complicated bacteriology of human arthritic lesions.

Case 11. M. C., a man, aged thirty-five, had a subacute form of tenosynovitis of the extensor tendons of the third and fourth digits, of two months' duration. The gross pathology was that of inflamed synovial tissue. As the tissue was too small for section, the whole of it was dropped in bouillon and cultured. The stained smear of the twenty-four-hour culture showed a scant growth of pleomorphic diphtheroid bacilli, but that of the forty-eight-hour culture showed micrococci in tetrads (micrococcus tetragenus). In subcultures on solid blood media, we differentiated certain dry, lemon-yellow *R* colonies in large heaped-up coccic blocks and cubes, which were identified as sarcina flava. We will not go further into the bacteriology of this case as another acute case of arthritis (Case 12), studied completely from its onset, gives ample opportunity for development in detail of these unexpected findings.

Case 12. R. C., a girl, seven years old, suffered from an acute form of arthritis of the right elbow. This was metastatic in origin and occurred in the course of a mannite-fermenting streptococcus hemolyticus (infrequens) mastoid infection complicated by septicaemia and sinus and jugular thromboses. No studies of pathological sections were possible, as the joint was simply incised and drained. The culture of the slightly purulent serosanguineous exudate gave a mannite-fermenting hemolytic streptococcus (Fig. 8) in all respects identical with the organism isolated from the original mastoid lesion, thus substantiating the metastatic nature of the elbow involvement. In subcultures for four successive generations, we did not see any morphological or biological deviation from the characteristics of the original type. Beginning with the fifth generation, we noticed the appearance of pleomorphic diphtheroid bacillary forms (Fig. 9) in bouillon media. Then, in the subcultures on solid blood-agar media, we isolated the typical lemon-yellow *R* colonies of sarcinae (Fig. 10), similar to those isolated in Case 11.

The type of sarcinae with which we were dealing was highly unstable in morphological and biological characteristics, readily dissociating into apparently unrelated bacillary and coccic forms, and reverting to the original streptococcus hemolyticus and even to the streptococcus viridans through the diphtheroid-bacillary phase and to staphylococcus aureus and finally staphylococcus albus through the micrococcus-tetragenus phase. We elaborated a life cycle of the arthrotropic streptococcus infrequens through its various phases of dissociation, as shown in Figure 12. Details

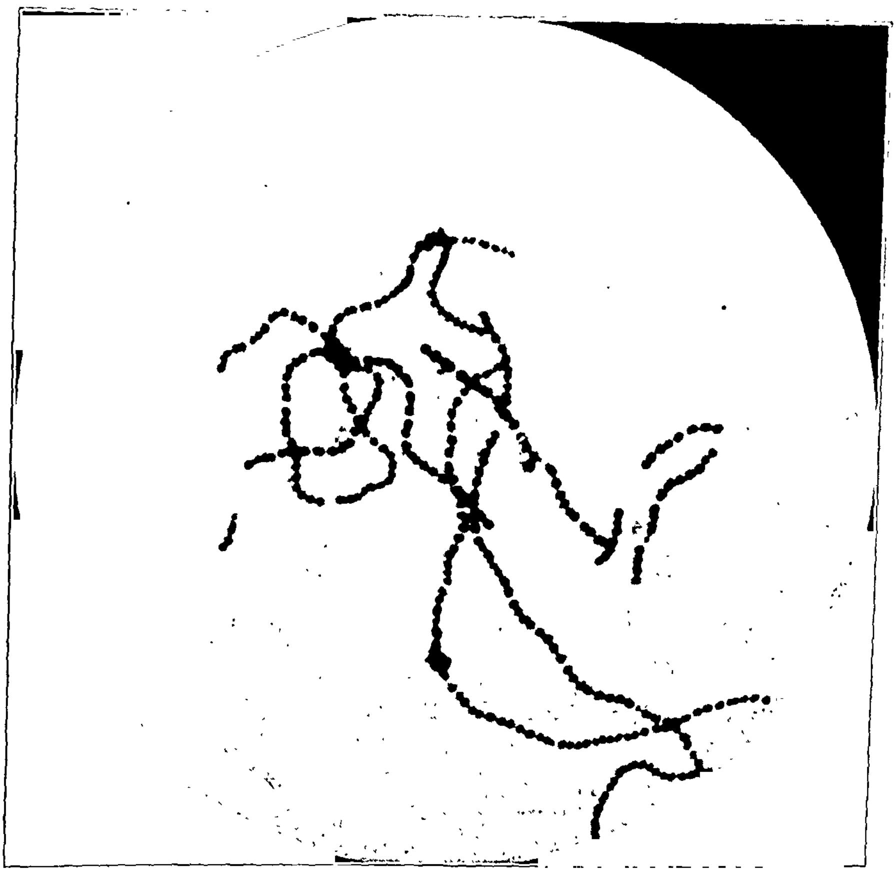

Fig. 8

Case 12. R. C. Gram stain (× 1,200).
The original streptococcus hemolyticus infrequens as isolated from the elbow joint on May 13, 1933.

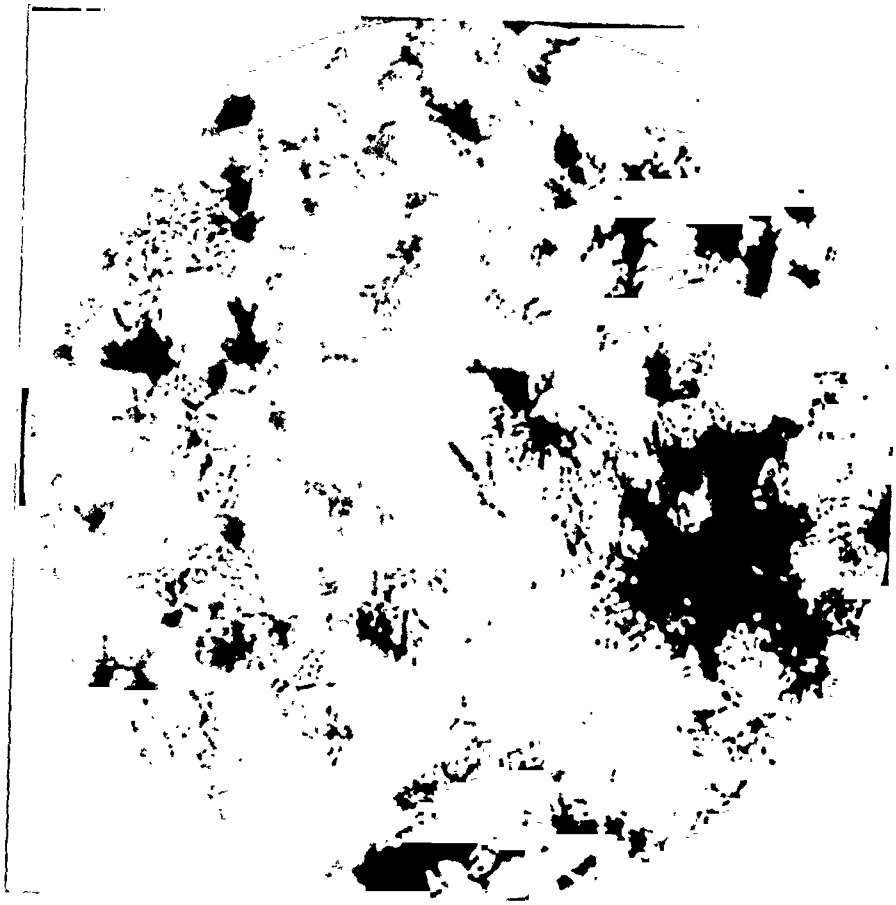

Fig. 9

Case 12. R. C. Gram stain (× 1,200).
The pleomorphic-diphtheroid phase appearing on May 20, 1933 in the pellicle of the bouillon culture of the fifth generation.

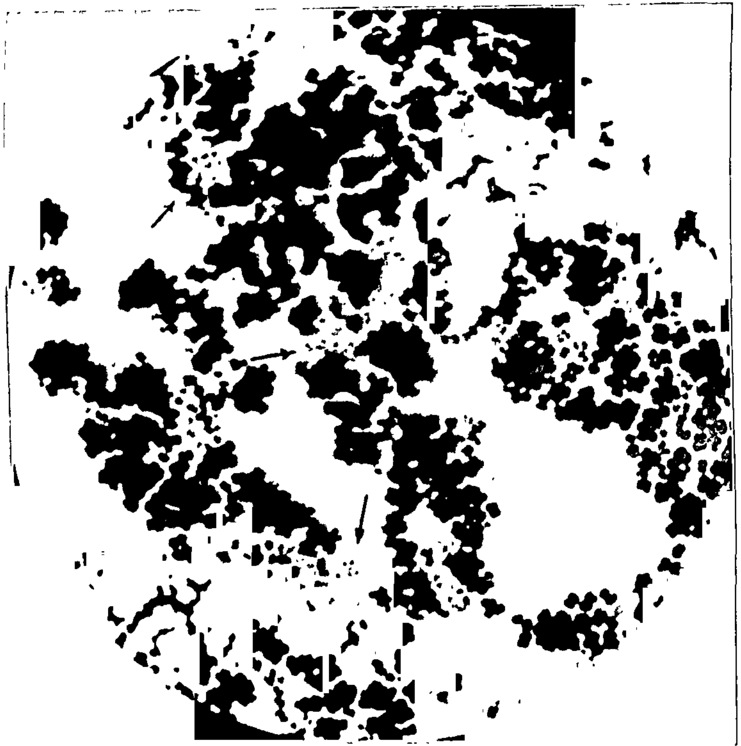

Fig. 10

Case 12. R. C. *Gram stain* (× 1,200).
The sarcinic phase succeeding the pleomorphic-diphtheroid phase within twenty-four hours. Note the minute, pale, granular masses between the sarcinic blocks as indicated by the arrows. Their actual size is [illegible] three-eighths of what it appears in the photomicrograph, due to the [illegible] of focusing on bodies of different dimensional values.

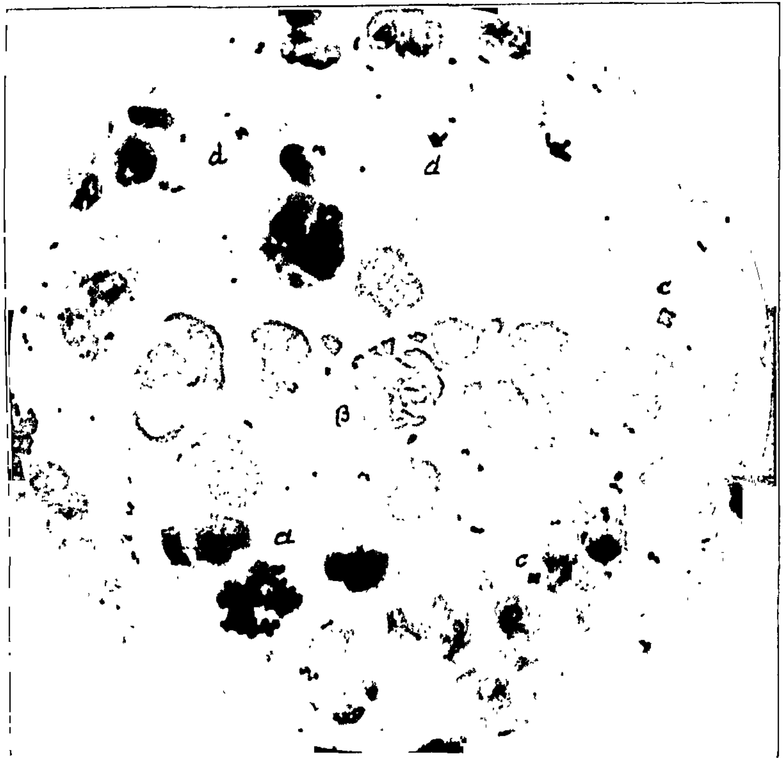

Fig. 11

Case 12. R. C. *Gram stain* (× 1,200).
Direct smear of joint exudate taken on June 17, 1933:
a: Pus cell showing phagocytosis of staphylococci.
b: Pus cell showing phagocytosis of diphtheroid bacilli.
c and *d:* Micrococcus tetragenus and diphtheroid bacilli free in joint fluid.

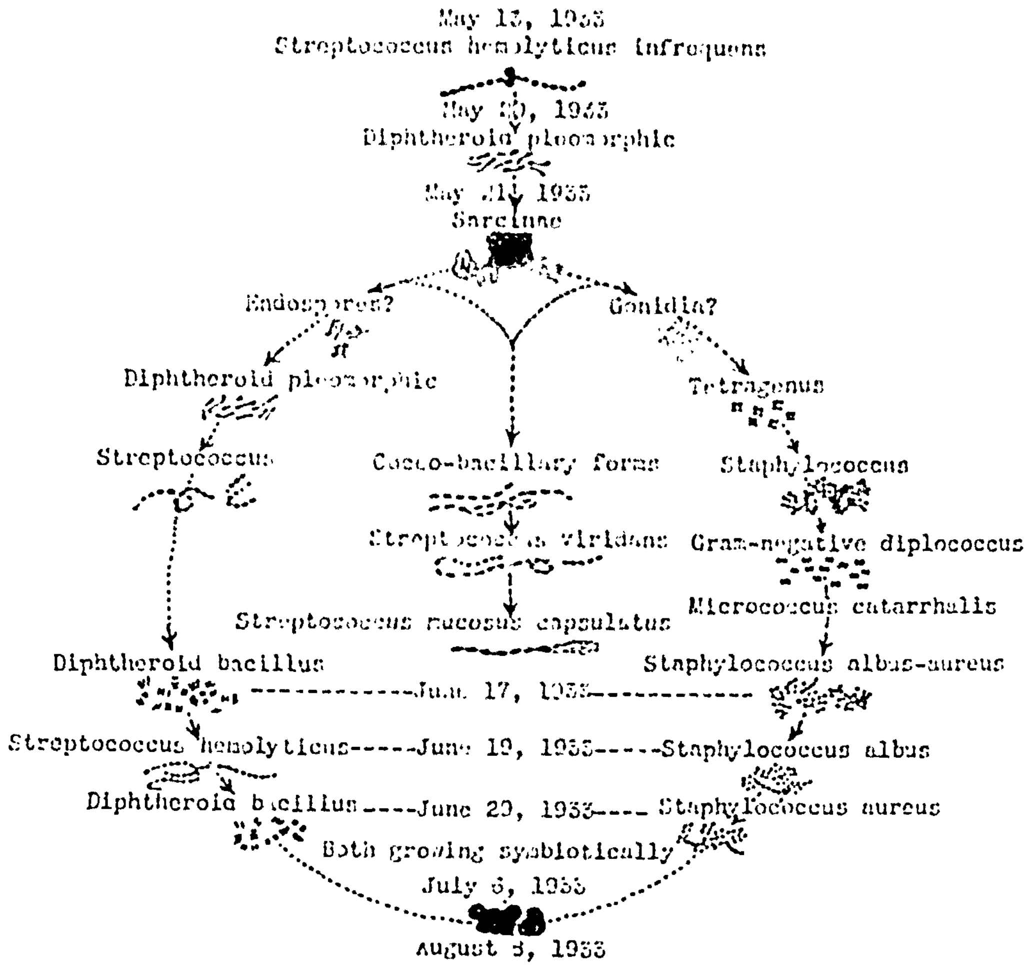

FIG. 12

The life cycle of a streptococcus hemolyticus isolated from Case 12.

of the bacteriological findings in these two cases, with their intricate serological interrelationships, will be given in a separate article.

COMMENTS

With due regard for the possibility of dealing with symbiotic colonies or even accidental contaminations, we might here emphatically state that all precautions were taken to eliminate such sources of error. It would, indeed, be even more difficult to account reasonably for so many widely different variations on the hypothesis of symbiosis, multiple infection, or even contamination.*

A further proof that, in obtaining these dissociants, we were not dealing with symbiotic life or accidental contaminations, but were actually bringing about *in vitro* what certain biological and immunological factors in the system of the host were working for *in vivo*, was found in the information obtained from the follow-up studies made in Case 12 of the progress, retrogression, and ultimate fate of this particular arthritic infection.

* Mellon, using the single-cell method in his research on the life cycle of tubercle bacillus, found that diphtheroid, micrococcic, and tetragenous forms invariably entered the picture.

In vitro, the time intervening between the streptococcic and sarcinic phases was eight days, May 13, 1933 to May 21, 1933. Final stabilization of the various dissociants (mutation forms), such as staphylococcus albus and diphtheroid bacillus, occurred in approximately one month, May 13, 1933 to June 17, 1933. The patient was discharged with a partially ankylosed and draining elbow joint on June 4, 1933. On her second visit for dressing, June 17, 1933, a thin, purulent discharge was still draining from the joint cavity. At this time, after carefully cleaning the skin area, we introduced a sterile platinum loop into the joint cavity and, from the material thus obtained, both inoculated a broth and took a direct smear. A photomicrograph of the stained direct smear (Fig. 11) showed a moderate number of pus cells and a few epithelial cells. The pus cells, as demonstrated in the photomicrograph, show a selective phagocytosis, some for staphylococci and others for diphtheroid bacilli. Among the freely floating bacteria, we could also detect a few tetragenous forms. The cultures yielded staphylococcus albus and diphtheroid bacilli. It may be a mere coincidence, but the fact remains that the time interval for the final stabilization of the changing flora into staphylococcus and diphtheroid bacilli, was the same *in vitro* and *in vivo.*

SUMMARY AND CONCLUSIONS

The evidence outlined would indicate that chronic rheumatoid arthritis may well be the result of a multiple mutant infection. The hypothesis is in line with the clinical course of the disease which, at the onset, may have all the earmarks of an acute infection (the streptococcic phase) before lapsing into the usual chronic form. Remissions, separated by shorter or longer periods of intermission, may be the clinical manifestations of the intricate immunological relationship of the streptococcic-dissociation forms,—the micrococcic-diphtheroid phase.

Up to two years ago, we could not satisfactorily explain why the serum of arthritic patients frequently reacted to a variety of apparently unrelated micro-organisms. The percentage of staphylococcic fixations in our records has always been high. Others have reported a variety of agglutinins for streptococcus hemolyticus as well as streptococcus viridans, for pneumococci and staphylococci.[1,3]

If we were actually dealing with a specific, immutable micro-organism with stable immunogenic properties, the course of the disease should not deviate from that of other acute infections,—that is, recovery, if the system is able to use its reactive defensive forces effectively, or death, in case it is overwhelmed by the extreme virulence of the invading organism. But if we have a streptococcus capable of dissociating into microbic forms that are less resistant to the immune mechanism, we feel that the natural tendency of the host would be to encourage such a metamorphosis. The bacteriological records of the twenty-one cases outlined support this hypothesis,—the active forms always yielding streptococci; the

moderately active, micrococci, either alone or with diphtheroid bacilli; the less active, diphtheroid bacilli; and, finally, the inactive or sclerotic forms being culturally sterile.

In concluding, we feel that, through a clear understanding of the mechanism of the immunological processes to which the human system resorts in bringing on these bacterial metamorphoses, we may some day have the main basis of a rational therapy for such chronic ailments.

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THE EFFECT OF LUMBAR SYMPATHECTOMY UPON THE GROWTH OF LEGS PARALYZED BY ANTERIOR POLIOMYELITIS *

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In 1930, one of us (R.I.H.) reported the effect of lumbar sympathectomy upon the growth of a lower extremity which was short as the result of a previous attack of anterior poliomyelitis. The patient was a girl, ten years of age, who eight years previously had passed through an attack of infantile paralysis which involved her left leg. There was an extensive paralysis of mild degree of many muscles in the leg. Shortness was the most conspicuous deformity. At the time of operation, it amounted to one and a half inches and necessitated the use of a raised boot. In the two years which followed operation, the shortness diminished to three-quarters of an inch and since then has decreased to half an inch. The earlier paper was in the nature of a preliminary report. We now propose to present the result of this form of treatment in a considerable number of cases.

The conception that lumbar sympathectomy might cause enhancement of the rate of growth of the lower extremity is based upon the observation that certain pathological conditions in growing children can result in overgrowth of the involved extremity. The diseases in which this phenomenon occurs are all accompanied by prolonged hyperaemia in the neighborhood of epiphyseal lines, usually the result of inflammation, but sometimes the result of passive congestion. This observation is amply supported by cases presented in the previous paper, and since then further cases illustrating this condition have been collected. Such varied diseases as synovial tuberculosis of the knee joint, hemophylic knee joints, Brodie's abscess of the lower end of the femur or the upper end of the tibia, arterio-venous aneurysms, hemangioma of the lower extremity, certain tumors of bone, prolonged low-grade inflammation of the soft tissues in the vicinity of the knee joint, and femoral thrombophlebitis have all resulted in overgrowth of the involved extremity. From our observations, it seems definite that prolonged increase in the blood supply of growing epiphyseal lines can cause them to grow more rapidly than would otherwise be the case. It is reasonable to expect that the increase in blood supply which follows lumbar sympathectomy would produce a similar effect. Our clinical experiences during the last five years lead us to believe that, under appropriate circumstances, appreciable enhancement of the rate of growth of the leg can be obtained by lumbar sympathectomy.

* Read before the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

LITERATURE

Since the publication of our previous paper, several writers have reported upon experiments designed to show the effect of lumbar sympathectomy upon the rate of growth of the lower extremity. Bacq observed no increase in the growth of the lower extremities of kittens and infant rats after complete unilateral sympathectomy. From observations based upon three kids and one half-grown monkey with partial paralysis of the lower extremities from poliomyelitis, Bisgard was unable to find any evidence of acceleration of growth in periods of observation of eight months and six months, respectively. On the other hand, Horton, reporting twenty-three cases of congenital arteriovenous fistulae, notes that overgrowth of the involved extremity is a nearly constant feature.

Pearse and Morton, in an excellent paper on the stimulation of bone growth by venous stasis, demonstrate by a series of experiments that fractures unite more rapidly in the presence of venous stasis than would otherwise be the case. Also they cull from the literature many interesting examples of overgrowth of the extremities, the result of venous stasis. These observations parallel our own in those examples of overgrowth of the lower extremity which have followed extensive thrombophlebitis of the femoral and iliac veins.

EXPERIMENTAL DATA

The result obtained in our first patient and the observations which we had made upon the circumstances under which overgrowth of an extremity can occur made some attempt at experimental investigation of the problem desirable. During the five years which have elapsed, we have undertaken three series of experiments upon kittens, puppies, and lambs. Ten kittens were operated upon under anaesthesia, and, by a transperitoneal approach, the left lumbar sympathetic chain was removed. In the kitten, the lumbar sympathetic chain is an exceedingly small and frail structure. Evidences of enhanced circulation to the leg in the form of increased warmth of the foot occurred in about half of the cases, but this effect was transient. In none of the kittens was the increased warmth as marked as it is in human beings, and in none was it sustained. Difficulty was encountered in rearing the kittens under laboratory conditions. Dietary disturbances and rickets resulted in the death of several. In the animals which reached maturity, definite evidence of overgrowth of the left lower extremity was lacking. In two cases, the bones of the left leg, removed at maturity, were longer than the bones of the right leg, but in both of these animals there was such a degree of rickets that the difference in length of the extremities could not, with certainty, be attributed to the effect of sympathectomy.

Twelve puppies were operated upon in a manner similar to the kittens (removal of the left lumbar sympathetic chain through a transperitoneal approach). In none of these animals was there clear-cut evidence of increase in the circulation of the left lower extremity as evidenced by

increased warmth of the left foot. They were sacrificed when they reached maturity and in none could definite evidence of overgrowth of the extremity be found.

Eight lambs were similarly operated upon. By a transperitoneal approach, the left lumber sympathetic chain was removed. On account of our previous observations that prolonged venous stasis could of itself cause overgrowth of the limb, in three of these animals the external iliac vein was ligated and divided, in addition to the sympathectomy. In one, an attempt was made to create an abnormal arteriovenous communication by anastomosing the femoral artery to the femoral vein. Those animals which reached maturity were sacrificed. Examination and measurement of the bones of both lower extremities have not yielded definite evidence of overgrowth of the left leg.

Our experimental results have not been satisfactory. Apart from the difficulty of maintaining young animals in good health under laboratory conditions, we have not succeeded in reproducing in them sustained increase in the circulation such as is seen in human beings following lumbar sympathectomy. To this we attribute our failure to obtain overgrowth of the extremities.

CLINICAL OBSERVATIONS

In attempting to assess the merits of this procedure by observations upon patients, certain difficulties are encountered. The first is to determine why a limb, paralyzed by anterior poliomyelitis, fails to grow as rapidly as its fellow. It is by no means clear just why this deformity occurs, nor does the problem lend itself to experimental investigation. The rate of growth of an extremity is the resultant of many factors, both local and general. In this problem we are concerned only with local factors. Most important of these is the inherent growth energy of the cells of the epiphyseal line. As long as these cells remain intact, growth will continue. Only by their destruction can we cause cessation of growth. However, the basic rate of growth may be modified by a variety of factors. We have already demonstrated that certain pathological conditions can increase the rate of growth,—arteriovenous aneurysm, prolonged inflammations, and prolonged venous congestion. In the normal limb also it seems certain that there are accessory factors which stimulate the cells of the epiphyseal line to grow at a rate which is somewhat greater than the basic rate due to the inherent growth energy. From prolonged observation, it is our belief that there are at least two such factors: first, the stimulation which comes from contraction of normal muscles; second, the stimulation due to a normal blood supply. In poliomyelitis both of these accessory factors are diminished or absent. The paralyzed muscles can no longer provide the stimulus which accompanies normal muscular activity. Either from lack of use of the limb or from some obscure disturbance of vascular control, the circulation is subnormal, as evidenced by the cold, blue extremity. Lacking these stimuli, the growth of the limb subsides to

a rate which is dependent upon the basic growth energy of the cells of the epiphyseal line, and hence this limb grows more slowly than the normal limb.

Assuming that the diminished rate of growth of an extremity paralyzed by poliomyelitis is the basic growth rate of the epiphyseal line, and that it lacks the enhancement due to muscle action and adequate blood supply, it is evident that any attempt to compensate this shortness by the increased blood supply which follows sympathectomy is dependent upon the restoration of only one of the normal stimuli. Even though the increase in blood supply is great and results in a vascular supply far in excess of normal, the resultant growth rate may still be less than normal if paralysis is extensive. Under such circumstances, the increased growth rate due to hyperaemia may not be sufficient to compensate completely for the diminution in growth which results from lack of the stimulus of active muscular contraction.

Following sympathectomy, three effects upon the growth of the paralyzed leg are possible:

1. The increase in the rate of growth may not be sufficient to result in a completely normal rate of growth. In this case, the limb grows more rapidly than before the operation, but the rate is still subnormal; hence, shortness continues, but less rapidly than formerly.

2. The increase in rate of growth may be sufficient to make the limb grow as rapidly as the normal limb. In this case, while the shortness which existed at the time of operation remains unchanged, no further increase of shortness occurs, as would otherwise be the case.

3. The increase in rate of growth may be sufficiently great to result in more rapid growth than the normal limb. In this case, the shortness will steadily diminish during the whole of the period of growth. It is even conceivable that the increase in rate of growth might be so great and might be continued over so long a period of time as to cause the short limb to become longer than the normal limb. This, however, has not yet occurred in our experience.

From the considerations already expressed, it is evident that the extent of the paralysis of the involved limb will greatly influence the result of sympathectomy upon the growth rate. If the paralysis is extensive, it is unlikely that the increase in circulation will so enhance growth as to cause diminution of the shortness which already exists. The loss of the stimulus to increased growth which comes from normal muscular activity is too great to be completely overcome by the stimulus of increased vascularity. On the other hand, if the paralysis is less extensive, actual diminution of the shortness may be expected, especially if the operation is performed early in the patient's life.

It is obvious that the age at which the sympathectomy is performed will exercise a profound influence upon the ultimate result. It is only during the period of growth that any influence can be brought to bear upon the rate of growth. Therefore, the earlier the child is operated upon, the greater will be the ultimate effect.

A further factor which we have found of importance is the necessity of performing an operation which will result in permanent increase in vascular supply to the limb. Our earliest operations were ramisections after the method of Royle. In a fair percentage of these, the immediate effect of sympathectomy was a marked increase in vascular flow, but, after the lapse of several months, this effect subsided to the condition which existed prior to operation. We have reoperated upon three of these patients, performing a ganglionectomy at the second operation. In each case, immediate increase in the vascular flow occurred and has remained unchanged to date. We are strongly of the opinion that for this particular problem ramisection is not the operation of choice. The operation should always be ganglionectomy.

CLINICAL CASES

In the five years which have elapsed since the publication of the report of our first case, seventy patients with short legs due to poliomyelitis have been operated upon by our associates or ourselves in an attempt to enhance the rate of growth by lumbar sympathectomy. We have recently reviewed forty-six of these cases, and our present summary is based upon this follow-up (66 per cent. of the total number of patients operated upon).

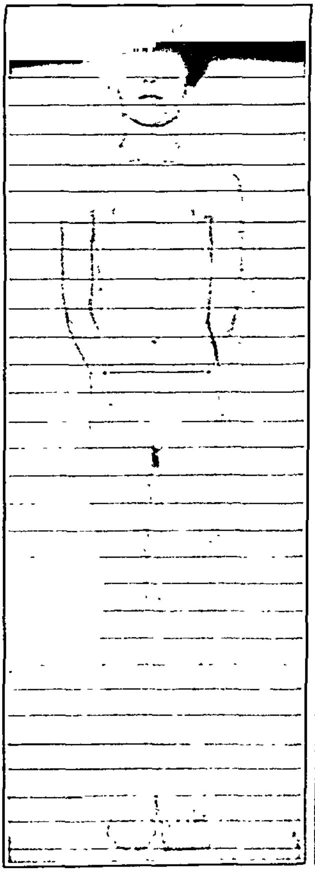

FIG. 1-A

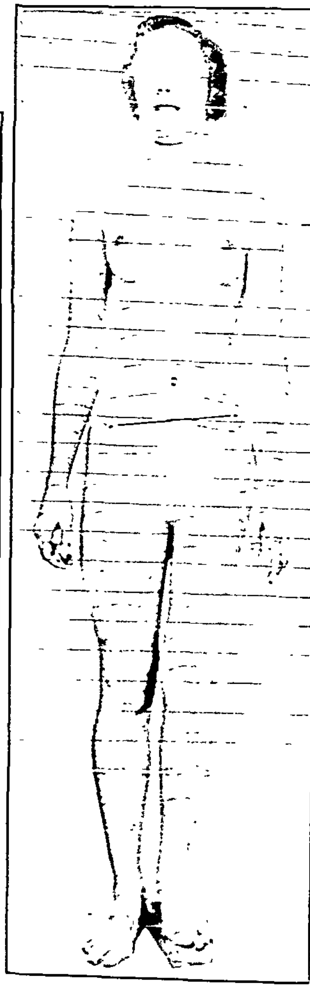

FIG. 1-B

Fig. 1-A: L. G., April 1928. Before ramisection. Shortness of left leg compensated by 1½-inch block.

Fig. 1-B: L. G., May 1934. Six years after successful ramisection. The block shown in Fig. 1 now raises the left side of the pelvis one inch.

NOTE: These and succeeding illustrations are reproduced from photographs taken with the patients standing behind screens of threads accurately spaced two inches apart. The black spots on the skin mark the positions of the anterior-superior spines. The interspinous lines have been drawn on the photographs to accentuate the levels of the anterior-superior spines.

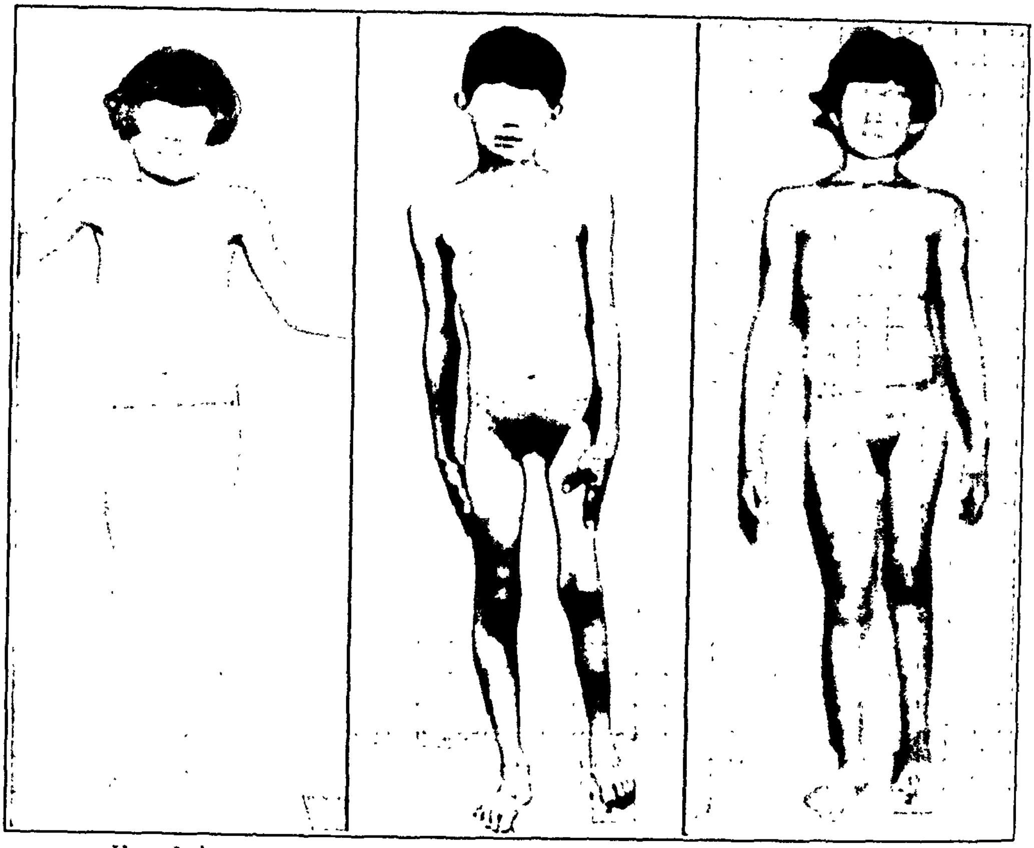

FIG. 2-A

E. R., April 1930. Before ramisection. Shortness of left leg compensated by 2½-inch block.

FIG. 2-B

E. R., October 1933. Three and one-half years after ramisection. Shortness of left leg now compensated by a 2-inch block.

FIG. 2-C

E. R., November 1934. One year after ganglionectomy. The same block shown in Fig. 2-B now elevates the left side of the pelvis one inch.

The first and most important outcome of our review is the demonstration of the fact that lumbar sympathectomy can appreciably enhance the rate of growth of a leg which is short as the result of infantile paralysis. It is our impression that a successful lumbar sympathectomy—*i.e.*, one which results in a sustained increase in circulation—always causes acceleration of the rate of growth. In not every case can this be proved, since even the enhanced rate of growth may still be subnormal in rate. Those cases, however, in which shortness is appreciably diminished present clear evidence of the beneficial effect of the operation. A situation which was causing progressive shortness is changed to one in which the involved extremity grows more rapidly than the normal leg and hence diminishes the shortness which already exists. In a less striking fashion, those cases in which the progress of the shortness ceases also demonstrate the value of the operation, since in them growth of the involved extremity has been increased sufficiently to keep pace with the normal limb.

A few case reports will serve to emphasize the fact that lumbar sympathectomy can greatly enhance the growth of an extremity.

L. G. was the first patient operated upon. Her condition was reported in our previous paper. She was ten years of age at the time of her operation. Her attack of infantile paralysis had occurred eight years previously at the age of two years. The left

leg was one and one-half inches short at the time of operation. There was extensive weakness of many muscles, although no complete paralysis. The operation was performed on April 25, 1928. She reached her mature height at the age of fifteen and has not grown materially since. In the two years which followed operation, the shortness diminished to three-fourths of an inch and, at fifteen years, the shortness was one-half an inch. The patient is now seventeen years of age and her leg is one-half an inch short. She walks without a limp and without a lift in her shoe, although she had a limp prior to her operation. (See Figures 1-A and 1-B.)

E. R., aged six years in 1930, had suffered infantile paralysis during her first year. On admission to the hospital, examination showed extensive paralysis of the left leg, varus deformity of the left foot, and two and one-half inches of shortness. The foot was stabilized by a Hoke arthrodesis and a left lumbar ramisection was performed. Three and a half years later, the shortness was two inches and the vascular effect of the ramisection had subsided. Lumbar ganglionectomy was, therefore, performed. This resulted immediately in the usual marked increase in circulation which has been maintained to date. One year after her second operation, the shortness was reduced to one and one-half inches. (See Figures 2-A, 2-B, and 2-C.)

D. F. aged twelve years in 1930, had passed through an attack of infantile paralysis at the age of three years. On admission to the hospital, examination showed extensive paralysis of the muscles of the left leg (especially those below the knee), drop foot, and one and one-half inches of shortness. Left lumbar sympathectomy was performed November 24, 1930. The increase in circulation has been maintained to date. Three years later, the shortness was reduced to one-half an inch. The foot has remained warm and dry. (See Figures 3-A and 3-B.)

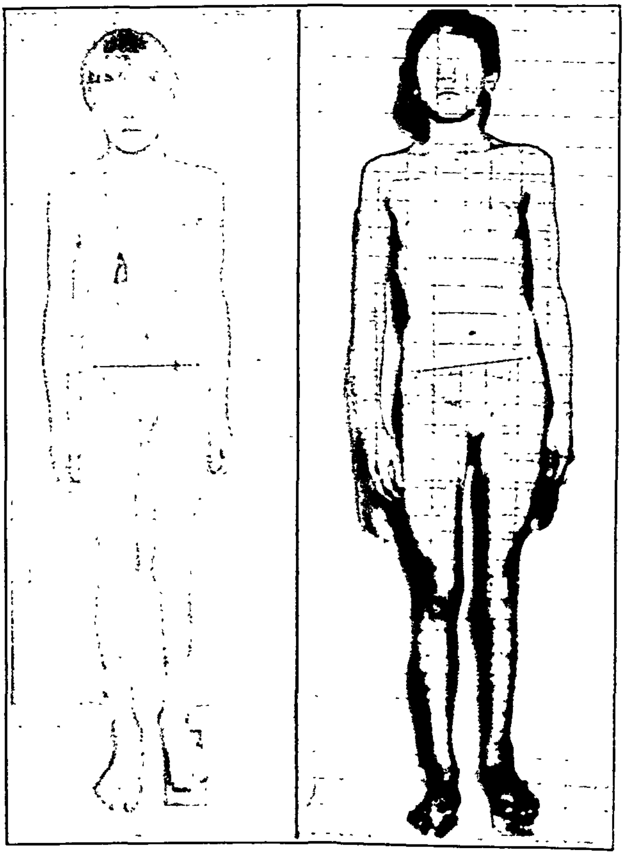

FIG. 3-A
D. F., November 1930. Before sympathectomy. Shortness of left leg compensated by $1\frac{1}{2}$-inch block.

FIG. 3-B
D. F., November 1933. Three years after sympathectomy. The same block shown in Fig. 3-A now elevates the left side of the pelvis an inch.

Important and striking confirmation of the fact that lumbar sympathectomy will enhance the rate of growth of growing legs has been obtained by examination of those children who were treated for Hirschsprung's disease by left lumbar sympathectomy. In

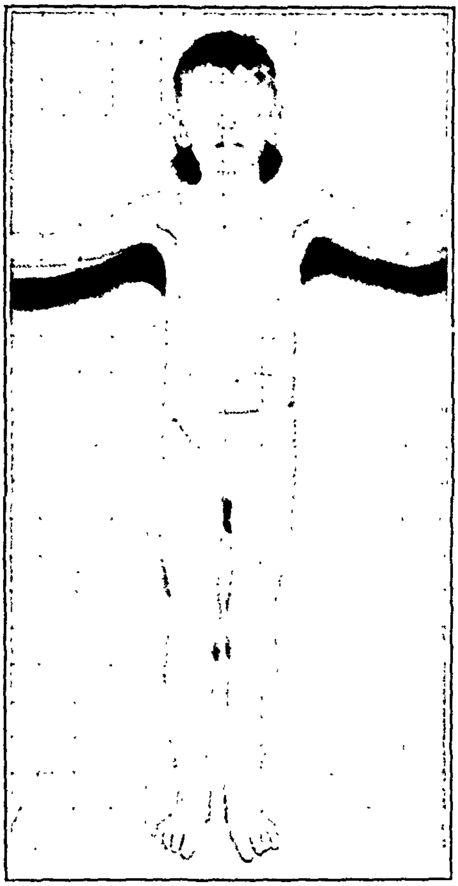

FIG. 4

R. T., six years old in 1935. The left leg is now three-quarters of an inch longer than the right as a result of left lumbar sympathectomy for Hirschsprung's disease four and one-half years ago.

our previous paper, we recorded and illustrated beginning overgrowth of the left leg (one-fourth of an inch) seven months after left lumbar sympathectomy had been performed for Hirschsprung's disease. This child has since died from causes not related to her primary disease and so is not available for reexamination at this time. However, among the seven patients who have been treated for Hirschsprung's disease at the Hospital for Sick Children in the last eight years, *there are three* upon whom the unilateral (left) lumbar ganglionectomy was performed. (The remainder were operated upon on both sides.) Examination of these three cases shows overgrowth of the left leg in each instance. The amount of overgrowth is as follows: R. T., a boy, now six years old, has three-fourths of an inch of overgrowth four years after left lumbar sympathectomy (Fig. 4); J. S., a girl, now four and one-half years old, has one-half an inch of overgrowth one year after left lumbar sympathectomy (Fig. 5); in the third case, that of a boy now eight years old, there is one inch of overgrowth five years after left lumbar sympathectomy. We have not been able to obtain a photograph of this patient.

OBSERVATIONS ON FORTY-SIX CASES REVIEWED

The forty-six patients whom we were able to reexamine constitute 66 per cent. of the number operated upon. Our failure to review a larger number is due to difficulties of transportation. Many of these patients live in outlying parts of the Province, several hundred miles from Toronto.

In twenty-one (46 per cent.) of the patients reexamined, the shortness had become less in amounts varying from one-eighth of an inch to one inch (Table I). In two cases the shortness was diminished by one-eighth of an inch; in six cases, by one-fourth of an inch; in seven cases, by one-half an inch; in four cases, by three-fourths of an inch; and in two cases, by one inch. The average age of this group at the time of operation was eight and one-half years. The time which had elapsed from operation to the period of review varied from seven years to one year. The amount by which the shortness is diminished is in propor-

tion to the time which has elapsed since operation. Sometimes, however, the rate of growth is very great and the shortness is diminished by three-fourths of an inch in one year. In one case, the shortness was diminished by one inch in one year. Much depends upon the rapidity with which the child is growing. Since children tend to grow rapidly at two periods, operation at these times may be followed quickly by striking change in the amount of shortness. It is particularly significant that in this group the effect of sympathectomy upon the vascular tree was permanently maintained in every case except one. In this patient the shortness has diminished by only one-eighth of an inch.

In eight cases (17 per cent.) in which lumbar sympathectomy was performed, the amount of shortness present at operation has remained unchanged. In other words, the progressive shortness has ceased. The rate of growth of the extremity has been enhanced sufficiently by the operation to equal the rate of growth of the normal limb. This may be fairly regarded as a definite beneficial effect from operation. The average age of this group was nine years. In one of these cases, the increased vascularity definitely was not maintained; and, in three others, the effect was slight.

These two groups represent the definitely beneficial results from operation and constitute 63 per cent. of the cases reviewed.

In seventeen cases (37 per cent.), the shortness progressed in spite of operation. The average age of this group was eight years. An extremely important observation in connection with these cases is the fact that in twelve (70.5 per cent.) the vascular increase which followed sympathectomy was not maintained.

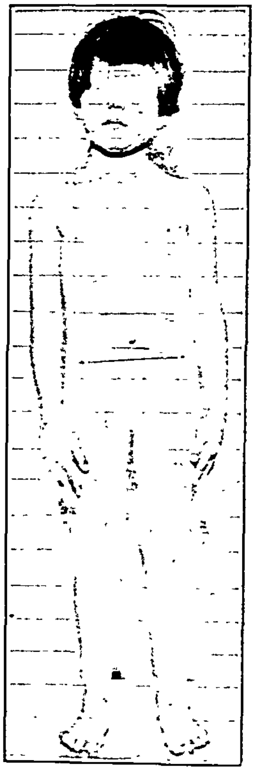

FIG. 5

J. S., aged four and one-half years in 1935. The left leg is one-half an inch longer than the right as a result of left lumbar sympathectomy for Hirschsprung's disease one year before the photograph was taken.

COMMENT

The most important observation which arises from a review of these cases is that, if the effect of sympathectomy upon blood flow is maintained permanently, the rate of growth of the extremity will be enhanced in a high percentage of cases. Thus, if we eliminate all the cases in which the sympathetic effect was not maintained, we have left twenty-nine cases. In twenty of these cases, the shortness diminished; in four, the progressive shortness ceased; and, in five only, the shortness increased. Therefore, in this group in which the sympathetic effect was maintained a beneficial effect upon rate of growth occurred in 82

TABLE I

EFFECT OF LUMBAR SYMPATHECTOMY UPON THE SHORTNESS OF THE LEG IN FORTY-SIX CASES OF ANTERIOR POLIOMYELITIS

Result	No. of Cases	Average Age	Vascular Effect Maintained	Vascular Effect Lost
Shortness diminished following operation....	21	8.5 years	20	1
Shortness remained as at time of operation..	8	9.0 years	7 (slight in 3)	1
Shortness continued to increase following operation..........	17	8.0 years	5	12

per cent., or in twenty-four out of twenty-nine cases. (See Table II.)

Success in securing a permanent effect upon the vascular system is obviously of great importance. To be of most value, the increased blood flow must continue during the whole growing period of the child—a matter of several years. Our early ramisections in many instances failed to maintain the central vascular response. Ganglionectomy is better in this respect, but even following this operation we have had several cases in which the vascular increase has not been permanently maintained. The cause of this occasional failure is not clear, for the operations were all similarly performed. The ganglionated lumbar chain was removed from the point where it emerges from the crura of the diaphragm to the point where it disappears in the pelvis. The material removed was submitted to histological examination. It is known that one failure was due to inability to find the trunk.

Examination of these patients reveals that the cases most favorable for obtaining a definite diminution of shortness are those in which the paralysis is moderate in degree. In cases of extensive paralysis, especially those in which all of the muscles of one leg are paralyzed, it is not likely that actual diminution of such shortness as exists at the time of operation will be obtained. At most, the progressive shortness will halt. Even this result is important.

TABLE II

BENEFICIAL EFFECT UPON SHORTNESS WHEN SYMPATHETIC EFFECT IS PERMANENTLY MAINTAINED

Result	No. of Cases	Per Cent.
Shortness diminished following operation....................	20	82.00 (with following row)
Shortness remained as at time of operation....................	4	
Shortness continued to increase following operation............	5	18.00

CONCLUSIONS

1. Prolonged increase in the blood supply to the lower extremity of a growing child can result in acceleration of the growth of the involved extremity.
2. The increase in blood supply which follows lumbar sympathectomy is capable, also, of inducing acceleration of the rate of growth.
3. The shortness which follows paralysis of the lower extremity from poliomyelitis is due to the loss of accessory factors which normally enhance the basic growth rate of the epiphyseal line. The known factors are the contractions of normal muscles and the maintenance of a normal blood supply.
4. Under appropriate circumstances, lumbar sympathectomy will diminish the shortness due to poliomyelitis.
5. The factors favorable to a good result are:
   a. Paralysis limited to one lower extremity.
   b. Paralysis moderate in degree.
   c. Early operation,—at the age of six years, if possible.
   d. Use of ganglionectomy rather than ramisection.
   e. Maintenance of the increased vascularity which follows the operation.

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OSTEOSYNTHESIS IN SPINAL TUBERCULOSIS *

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AND MARCEL GALLAND, M.D., BERCK-PLAGE, FRANCE

TRANSLATED FROM THE FRENCH BY ALAN H. TODD, F.R.C.S., LONDON, ENGLAND

The evolution of Pott's disease lasts a little more than three years. Throughout this period, the patient must remain recumbent, rigorously immobilized upon the plaster bed which is described later. The treatment is strictly conservative. No operative attack upon the focus of disease is ever practised. Throughout the whole course of recumbent treatment, the greatest care is taken to induce orthopaedic correction of deformity. In this respect, lumbar disease contrasts strikingly with dorsal disease.

Lumbar Pott's disease is easy to correct. The lumbar vertebrae are normally somewhat pressed together posteriorly, owing to the lumbar concavity, and, therefore, have a tendency to spontaneous intrafocal correction. Furthermore, lumbar lordosis close to the focus of disease is easy to achieve, thanks to the normal hyperextensibility of the lumbar spine. Hyperlordosis is attained, upon the orthopaedic table, by placing the patient prone and then simply lowering a central support. While the patient is in this position, the plaster bed is made. (See Figure 1.) Throughout the whole course of treatment, the patient lies upon this bed, which is renewed every three months.

This method is not applicable, however, in cases of dorsal disease. If the bed were made in this way, one would obtain only a lumbar lordosis, and would fail to attain hyperextension immediately above and below the focus of disease. Such lumbar lordosis would be objectionable in that it would render the dorsal gibbus more apparent. Accordingly, the patient is placed in the ventral position upon the orthopaedic table, but the central support is raised in order to prevent the development of any lumbar lordosis. A wedge of cotton-wool is now placed upon the back, at the level of the vertebra just above the diseased area; the higher the disease, the thicker the wedge. The object of this is to produce lordosis immediately above the focus of disease. Plaster is next modeled on top of the cotton-wool and to the back below this level. The cotton-wool is taken away, of course, before the patient is placed upon the plaster bed.

What are the indications for vertebral osteosynthesis in these conditions? This procedure should be carried out only at the end of treatment. If the operation is performed earlier, it interferes with the process of consolidation of the posterior segments of the vertebrae, which is a factor in intrafocal correction of deformity. Moreover, experience

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has proved that premature osteosynthesis does not shorten the duration of the disease, nor enable the patient to become ambulatory any earlier. It delays the evolution of the disease, but does not arrest it. It does not prevent increase of gibbus, formation and persistence of abscess, or paraplegia. In view of these facts, it is obvious that osteosynthesis should be practised only at a late stage, when the evolution of the disease has come to an end, and some months before the moment at which, according to classical conservative procedure, the patient would be allowed to begin to walk again. Osteosynthesis by means of a bone graft plays the part, then, of a protector, an internal orthopaedic corset, and a safety bolt, and it may aid in the cure by acting as a recalcifying agent.

The operation is carried out under local anaesthesia, by infiltration of all the tissues in the dorsal region. When the graft is taken from the tibia, the whole operative area is encircled and the nerve supply is blocked as it enters the nutrient foramen.

Our technique consists in the application of two short grafts, limited to the focus of disease and not extending to the vertebrae above and below this focus. Two rigid grafts, placed lateral to the spinous processes, are employed in the case of lumbar disease, and two supple or semisupple grafts in the case of dorsal disease. These grafts are applied after section of the spinous processes and roughening of the laminae.

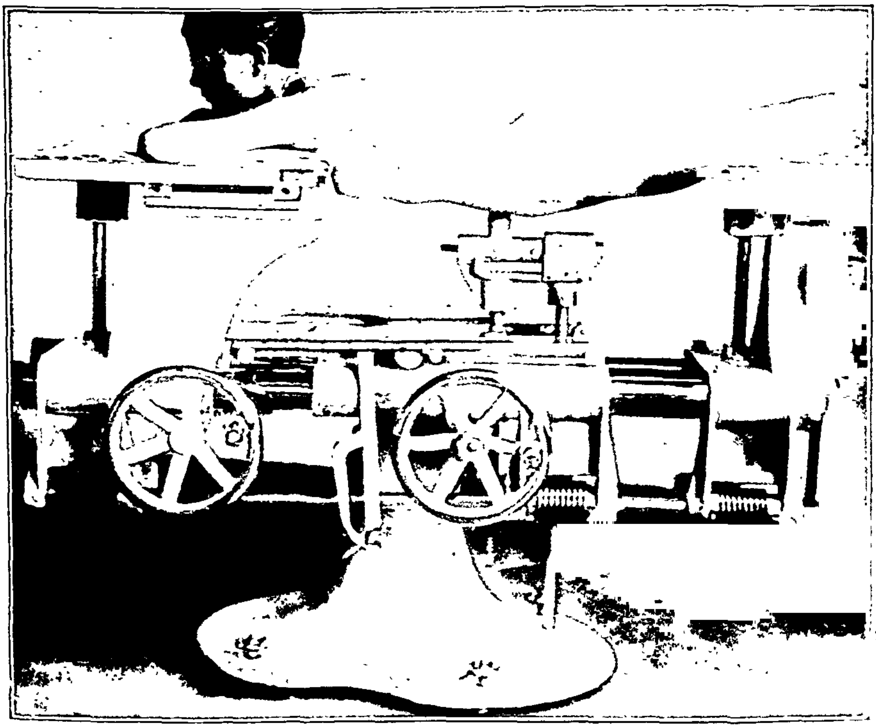

FIG. 1

Galland's orthopaedic table, showing patient in position for the application of the lumbar plaster bed.

Why do we use short grafts, limited to the immediate area of disease? Because experimental study of the mechanics of the condition and the observation of anatomical specimens have shown that the graft never fractures, undergoes absorption, becomes decalcified, or lengthens, except at the level of the focus of disease. Accidents of this kind are never observed above or below this area. It is evident, therefore, that bony material must be deposited in maximum amount at this level only. Furthermore, the long graft is objectionable, in that it hinders the development of compensatory curves above and below the diseased vertebra and prevents compensatory changes in the healthy intervertebral discs. There is also the danger that it may act as a rigid lever and thus serve to multiply a flexional strain which is at all times disadvantageous.

Special tools which are used in our operations include the electrically-driven saw of de Martel, Galland's apparatus for fixing the leg during the separation of the graft, Ombrédanne's chisel (used in freshening the spinous processes), Hue's chisel, and curved gouges for roughening the laminae in the dorsal part of the spine.

NOTE: The discussion of other phases of the subject also included in the presentation at the Meeting will appear in a subsequent issue of *The Journal*.

ARTHRODESIS OF THE HIP FOR COXALGIA IN CHILDREN *

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TRANSLATED FROM THE FRENCH BY ALAN H. TODD, F.R.C.S., LONDON, ENGLAND

A certain number of children can be cured by orthopaedic and climatic treatment, if this treatment is instituted early.

The number of "cures" has been reduced by the differentiation of Legg-Calvé disease and a number of other non-tuberculous conditions, and the number is still further reduced, if the various bacteriological tests for tuberculosis that are now available are rigorously applied.

By the term "cure" one should mean that the disease is arrested, suppuration has been prevented, the articular surfaces are unaltered in shape, and the mechanics of the affected joint are unimpaired. Furthermore, the joint should function painlessly, and there should be no relapse.

In the case of a child in whom the process of natural cure has not resulted in ankylosis in good position or useful function at the joint, the coxalgia should be cured, and the solidity and painlessness of the joint should be insured by the performance of arthrodesis.

When there is considerable destruction of bone, it is unnecessary to wait for any great length of time in the hope that good function will ultimately be regained; nor is it essential to wait until the local pathological process has come completely to an end. Operative treatment need be delayed only until the general health of the patient has been improved by immobilization under favorable climatic conditions (especially by residence at the seaside) and until the stage of bacillaemia is thought to be past. It is important, also, to satisfy oneself that there is no abscess present which would be encountered in the course of operative interference.

Since the greater trochanter does not ossify until eleven years of age, a graft should not be implanted in the trochanter of a child, but in the upper part of the femoral shaft. However, both in children and in adults, the author prefers not to use a graft, because this material dies and is liable to be absorbed a long time before it has been reossified and has become solid. The technique used is that of the "*pont-levis*", described by the author in 1932[1], which has been adopted by our Italian colleagues, Raffaele Zanoli and Ugo Camera, under the name of "*ponte-levatoio*". This operation does not involve the use of a bone graft in the ordinary sense, but, rather, a thin layer of the outer table of the iliac bone and its periosteum. This layer is left firmly attached to its bony base or origin.

* Presented at the Spring Meeting of the British Orthopaedic Association, Berck, France, April 26, 1935.

but is bent in a hingelike manner, and its tip is then embedded in a split made in the trochanter. If the hip is in a faulty position which cannot be corrected by manipulation under anaesthesia, a subtrochanteric osteotomy is also performed. The hip is immobilized in a plaster cast which reaches to the knee. The author uses the orthopaedic operating table, designed by Lance, which permits the application of the plaster immediately after the operation, without changing the patient's position.

Four months after the operation, the patient is allowed to walk. After a further period of six months, during which the bony bridge undergoes considerable hypertrophy, the patient is allowed to walk freely, without apparatus of any kind.

The immediate results are good. The gait is confident and easy, and the patient is free from pain. The residual limp can never be wholly disguised, but the patient learns to mask it by compensatory movements of the pelvis and of the knee. The earliest cases in which this procedure was used date from 1926, and the late results show that relapse does not occur after an arthrodesis which effectually immobilizes the hip.

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TREATMENT OF QUIESCENT TUMOR ALBUS AND PSEUDARTHROSIS OF TUBERCULOUS ORIGIN IN CHILDREN *

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TRANSLATED FROM THE FRENCH BY ALAN H. TODD, F.R.C.S., LONDON, ENGLAND

For the past seven years, at the Maritime Hospital in Berck, on the Service of Dr. Richard, efforts have been directed toward the improvement of the technique and end results in cases of tumor albus of the knee.

A fairly large proportion of these cases are of five to six years' duration. When untreated, or treated on conventional lines, these patients are left at the age at which resection is appropriate with very real disability, which has a tendency to increase in severity.

In certain knees, the disease appears to be arrested, but the patient is left with a movable, unstable, painful pseudarthrosis which is a frequent source of pain and of relapse. Slight deformities become greater, and give rise to serious consequences, in spite of the conscientious application of all the ordinary accepted principles of treatment. Prolonged splintage does not suffice to prevent this unfortunate result.

Correction of deformity by manipulation alone, or by osteotomy, is merely palliative and does not overcome the mobility at the joint, which is the fundamental cause of the repeated and late relapses. Long ago, Broca showed that intra-epiphyseal resections were unreliable, as far as their end results were concerned, and we, too, have found that even the most careful operations, performed upon epiphyses that are still soft and growing, are liable to be followed eventually by serious deformity.

In the hope of overcoming this difficulty, various workers have adopted entirely different principles of treatment. Vignard and his associates have tried enucleation and filling of the epiphysis, while Robertson-Lavalle and others have used transepiphyseal grafts. The results of these procedures have been so uncertain, that we have made no regular use of the methods.

The striking success of arthrodesis of the hip in cases of coxalgia has encouraged surgeons to try to apply a similar procedure to cases of quiescent tumor albus of the knee. The method is also applicable to cases of old and severe pseudarthrosis, especially when, because of the patient's age, a standard resection of the knee is impossible.

There are available several different methods of inducing fusion in the slowly developing forms of disease in the knee, such as the unstable, painful, movable knee joint.

Intra-articular arthrodesis by transepiphyseal bone-pegging (the classical method of Lexer, Tuffier, and Lance) has been simplified by Richard

* Presented at the Spring Meeting of the British Orthopaedic Association, Berck, France, April 26, 1935.

and has often been employed by him in older children. After removal of the articular cartilages, a rigid graft, taken from the tibia of the healthy limb, is driven obliquely through the epiphyses. The results obtained by this very simple method are good. However, the method should be restricted to cases in which there has been no gross destruction of the epiphyses and in which recalcification has very largely taken place; it should, moreover, be confined to the dry forms of the disease. In spite of these precautions, the graft sometimes becomes absorbed and breaks in the space between the femur and the tibia.

Juxta-epiphyseal arthrodesis by means of peripheral grafts, after the manner of Dupuy de Frenelle, also gives good results. Several series of favorable statistics have been published, especially by Italian surgeons.

Both of these methods are open to the objection that it is necessary to open the joint through tissues in which the disease is by no means extinct.

In 1933, we perfected a completely extra-articular method of arthrodesis,—namely, anterior femoro-patello-tibial arthrodesis. A long, supple, curved graft, of ample thickness, is cut from the tibia of the healthy limb and is fixed at each end into two notches in the femur and tibia respectively, while, at the center, it is slipped beneath two flaps cut from the anterior surface of the patella.

Since the introduction of this method, we have employed it in more than thirty cases. At the present time, we use it only in the more chronic forms of the disease, and in children who are over ten years of age. We have found that in younger children the deformity is liable to recur later on, in spite of the correct application of the graft at operation.

Although sufficient time has not elapsed to warrant the drawing of conclusions, we do not believe that the ultimate growth of the limb is liable to be arrested. In order to avoid any possible trouble from this source, we prefer at present to perform the operation only on children in whom epiphyseal growth and ossification are relatively advanced.

The technique is delicate, because of the difficulty of taking the graft correctly. At first, there resulted several cases of pseudarthrosis and of fracture of the graft, although these mishaps were easily remedied. There are certain devices whereby errors in technique may be overcome. For instance, if a graft proves to be too short, it may be divided transversely in the middle: one piece is then affixed to the upper margin of the patella; the other, to the lower. Zanoli employs a very similar method, with success. He uses a long, pedicled, tibial graft which he bends backward and attaches to the femur. The two methods can be employed in combination.

With or without modification, the operation is of value if used in well selected cases, and insures good consolidation. Abundant proof of the solidity of the knee has been forthcoming on many occasions. The most typical case is that of a girl of fourteen with a severely paralyzed knee, a much shortened limb, and such severe trophic changes that intra-

epiphyseal resection was quite out of the question. An arthrodesis of the type described was performed and, when examined two years later, the patient showed an excellent result.

At the age that we are considering, a certain number of cases of severe tumor albus show arrest of active disease, with imperfect fusion of the bones and deformity. When the deformity is severe, the classical methods of correction are notoriously inadequate. For the last seven years, we have been employing a very useful method of obtaining the necessary correction,—namely, posterior capsulotomy by an anterior approach. By this means, it is possible to divide the contracted posterior portion of the joint capsule at the level of the articular condyles and to obtain complete extension of the joint, without interference with the bones themselves. We consider this to be the method of choice in the treatment of severe flexional deformity of the knee, whether simple or complicated. As a preliminary measure, it is wise to carry out tenotomy of the hamstrings and the tendo achillis. When full extension has been restored, its maintenance can be insured by the performance of an arthrodesis.

These various operative measures now provide adequate treatment for forms of the disease which hitherto have been treated only with imperfect success.

SURGICAL TREATMENT OF SACROCOXALGIA*

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From the Maritime Hospital, Berck-Plage

Sacrocoxalgia is rare in the child, who is more likely to develop juxta-articular osteitis, often of the benign type. The treatment is preventive, with the object of avoiding articular involvement. On the other hand, sacrocoxalgia is frequent in the adult. Fifty-four cases have been seen in the Maritime Hospital at Berck since 1930. If a tuberculous lesion is present, the prognosis is grave, but it may be considerably ameliorated by well directed treatment.

To be efficient, treatment should be begun in the early periods of the development of the affection. The principle of this therapy consists essentially of thorough and prolonged immobilization of the patient, under the most favorable hygienic conditions, in order to aid him in combating the tuberculous infection. These conditions are found in the marine heliotherapy which is indispensable to these patients. Immobilization is obtained by the usual orthopaedic methods and, still better, by well directed surgery.

Sacro-iliac arthrodesis, in addition to the biological influence of the graft, is also an aid to immobilization. Two procedures are commonly employed,—the arthrodesis by the peg or graft and the double extra-articular arthrodesis, as practised by Dr. A. Richard, Surgeon-in-Chief at the Maritime Hospital at Berck.

In the arthrodesis by the graft or peg, a solid graft, two centimeters in thickness and from six to seven centimeters in length, is taken with the chisel from the internal surface of the tibia and is narrowed at one of its extremities. A curved incision along the crest of the ilium allows the exposure of the posterior part of the external iliac fossa. The point of entrance of the graft is then marked. This point is determined according to the indications of Piéri,—at four centimeters from the top of the posterosuperior iliac spine and at three centimeters from the external surface of the iliac crest. The drill is entered perpendicular to the surface of the ilium to direct the course of the graft, which passes through the iliac bone and the wing of the sacrum.

For the double extra-articular arthrodesis, a solid graft, one centimeter thick and twelve to fifteen centimeters long, is taken and is cut into two pegs of equal length. A long curved incision, with the concavity inferior, exposes the posterosuperior iliac spine and the crest of the sacrum. After the marking and drilling, the bone grafts are placed in position from the spine of the ilium to the first two spinous processes of the sacrum.

*Presented at the Spring Meeting of the British Orthopaedic Association, Berck, France, April 26, 1935.

To obtain from the arthrodesis the results which one should reasonably expect, it is necessary to understand thoroughly the indications and to employ this method at the proper time, under well controlled conditions, and according to a definite technique.

It is very important that the field of operation be free from all infection, and it is for this reason that arthrodesis by graft is not applicable except to localized forms of sacrocoxalgia,—that is, those situated in the lower portion of the sacro-iliac joint. The double extra-articular arthrodesis of Richard is applicable to all cases, for it gives increased security from the technical point of view.

The operative procedure, however, is not the chief consideration; much more important are the indications for its use. The arthrodesis should be performed early, but conservatively,—that is, the patient should always be prepared for this operation by several months' rest under the best climatic conditions. Marine heliotherapy exerts a most favorable influence upon the defensive reactions of the organism against bacteriological infection which contra-indicates the operation.

Arthrodesis should be performed only when the surgeon is sure that the operative area is free from infection and that no abscess exists. One should never run the risk of opening a focus during the operation.

The postoperative care is necessarily prolonged. The general treatment and rest should be rigorously continued for six months after the operation. Arthrodesis is not a curative treatment; it is simply an adjuvant of first importance and should not be considered as the only therapeutic measure.

In sacrocoxalgia with infection, it is absolutely necessary to obtain a thorough drainage of the lesion. The infected abcess should be given a thorough débridement. A deep, infected area drains imperfectly and should be treated by resection,—either by an atypical resection, according to the method of Ollier, or by a partial resection, according to the method of Picque.

After the posterior iliac spines have been exposed, the posterior surface of the sacrum is removed by the chisel, thus exposing the articular area which is then evacuated according to the indications. This process frequently extends in front of the articulation and thus drains the collection in the pre-articular space.

Infection constitutes the most grave complication of sacrocoxalgia, but well conducted treatment—arthrodesis performed at the opportune time and according to the principles which have been explained—should prevent infection.

CHRONIC OSTEOMYELITIS ASSOCIATED WITH MALIGNANCY

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Malignant change following chronic osteomyelitis with draining sinuses has been recognized for many years, but the condition has been so rare that many of the papers written have been reports of single cases. There seems to have been more interest in this subject in the years prior to 1910 than there is at present, probably because the treatment of chronic osteomyelitis with draining sinuses was not as adequate then as it is now. Benedict [1] reviewed the subject thoroughly in 1931. Of 2,400 cases of chronic osteomyelitis treated at the Massachusetts General Hospital, he found twelve in which the osteomyelitis was associated with carcinoma. In each case the carcinoma was in the lower extremity. The tibia was involved in eight cases, the foot in three, and the femur in one. Benedict, like earlier authors, recognized two types: the superficial tumor, easily diagnosed, and the deep tumor in which the carcinomatous cells line the walls of the cavities which are produced by the osteomyelitis.

Of 2,396 cases of chronic osteomyelitis seen at The Mayo Clinic up to July 1, 1934, only five, or 0.208 per cent., were associated with malignant changes. Of these patients, one was a woman and four were men. The ages varied from forty-five to sixty-one years, averaging fifty-two and two-tenths years. Draining sinuses of chronic osteomyelitis had been present from twenty-seven to forty-eight years; the average period was thirty-seven years. In four cases, the disease had followed acute osteomyelitis; and, in one case, it had followed a compound fracture. In all of these cases there was a history of sinuses which had closed and then opened again at a later date, sequestration of bone, and other symptoms characteristic of the behavior of chronic osteomyelitis.

The reasons given for seeking medical advice after so many years of chronic disability were much the same in each case,—swelling, increase in pain, hemorrhages, and more profuse discharge. The appearance of an abnormal growth within a few months before coming to the Clinic was the reason advanced in two cases.

On examination, the typical draining sinus surrounded by scarred skin was seen in each case. In one case, a growth the size of a tangerine (6.2 centimeters) was found. In another case, an ulcerating area, four inches (10.16 centimeters) in diameter, which was the site of a cauliflower-like growth, was seen. In a third case, there was revealed a discharging sinus, the size of a silver dollar (3.5 centimeters), which had raised edges

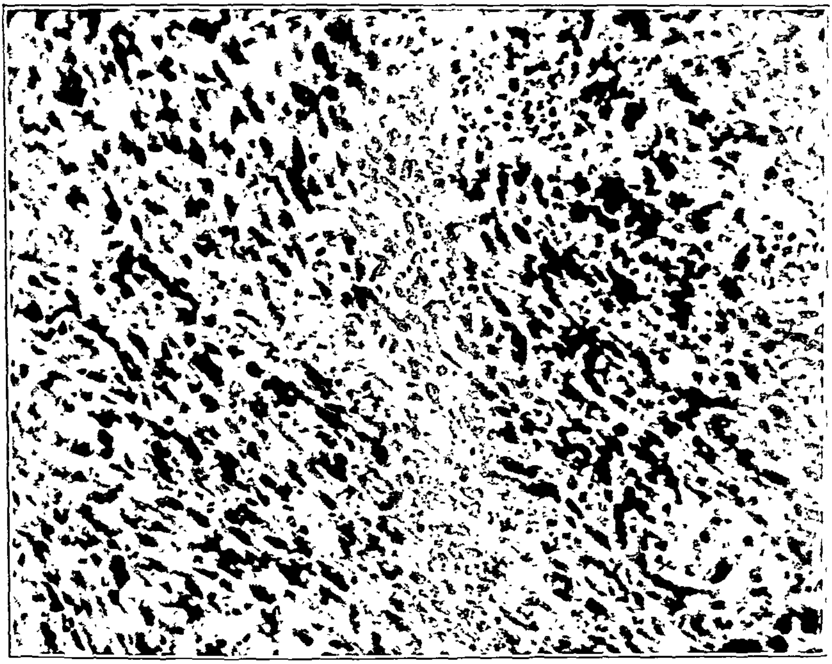

Fig. 1
Fibrosarcoma, grade 3 (× 215).

and resembled an epithelioma. The fourth patient presented a draining sinus in close proximity to a swollen, tender ankle. This was the patient who had had hemorrhages. The fifth patient presented a foul-smelling, fungating, papillomatous mass. A foul odor was mentioned in two cases. In four of the five cases, the regional lymph nodes were found to be enlarged and firm. Interference with joint motion, which was the result of the osteomyelitic process, was found in two cases. In four of the five cases, roentgenograms showed the typical irregular sclerotic changes always seen in chronic osteomyelitis.

Examination of the urine and blood did not reveal anything of importance. The Wassermann reaction of the blood was negative in four of the five cases.

In the first two cases, amputation was at once performed. In the other three cases, a biopsy was done first.

In four cases, the lesion was situated in the lower third of the leg. In three of these cases, amputation was performed at the junction of the middle and upper thirds of the leg; in the other case, a Gritti-Stokes operation was done. In the fifth case, in which the neoplastic process was near the hip joint, local excision was done, followed by cauterization and the use of deep roentgenotherapy and radium. As in Benedict's series, the lower extremity was involved in all of these cases.

The pathological findings revealed: epithelioma, grade 1, in two cases; epithelioma, grade 2, in two cases; and, in the other case, fibrosarcoma, grade 3, which was associated with squamous-cell epithelioma, grade 3.

FIG. 2
Squamous-cell epithelioma, grade 3 (× 95).

This was the only case in our series in which sarcoma and carcinoma were associated, and we were able to find reference to only two other cases in the literature. The patient in our case was a man who had suffered a compound fracture of the lower ends of the tibia and fibula in 1911. Chronic osteomyelitis had developed, and, as the patient lived near the Clinic, he was seen at intervals thereafter. The sinus was curetted twice and skin grafts were applied once, but they did not live. In 1933, the patient had a great deal of pain and, after two hemorrhages had occurred, a biopsy was done. This revealed fibrosarcoma, grade 3. The leg was amputated a week later. The stump healed, but, four months later, a large mass appeared in the groin of the involved side, which on excision proved to be squamous-cell epithelioma, grade 3.

Two of these patients received roentgen-ray and radium treatment postoperatively, and one received roentgen-ray treatment.

An attempt was made to determine the results of treatment in these cases. Two patients, who underwent amputation in 1925 and in 1929, respectively, were well and had good functioning stumps in June 1934. There had not been any local recurrences or evidence of metastasis in either case. Each of these patients had an epithelioma, grade 1. The patient who underwent an amputation in 1924 died of chronic nephritis in March 1935. He had not had any further trouble with his stump or any extension of the disease to other parts of the body. He had an epithelioma, grade 2. In the case in which local excision of the tumor was performed in 1921, the patient died at a later date, but the cause of

death could not be determined. The neoplasm in this case was epithelioma, grade 2. The patient whose leg was amputated for mixed fibrosarcoma and epithelioma in 1933 is in good health at the time of this report.

COMMENT

The rarity of the condition is evident when it is seen that it was found only five times in 2,396 cases of chronic osteomyelitis. The long history of drainage of pus from sinuses antedating the appearance of the growth is similar to that reported by other authors. The disease has always been found to affect males more frequently than females, and this was true in our series. The lower third of the tibia was involved in four cases and the femur was involved in one case. While enlarged inguinal lymph nodes were palpated in the groin in three cases, the involvement was not proved to be metastatic. No other evidence of metastasis was found. In the case in which sarcoma and carcinoma were associated, the growth of the inguinal mass followed the amputation and was a distant recurrence.

The reason for the growth of carcinoma in these cavities and sinuses has always been in dispute. The theory which most commonly is accepted is that the continuous drainage of pus irritates the skin to such a degree that malignant changes result. Why this should happen in so few cases is not clear. It may be that the resistance of the skin of middle-aged r elderly people is lessened, so that irritation from pus, which would have .o effect on the skin of younger people, is able to initiate neoplastic .hanges. This conforms with the frequent finding of carcinoma of the skin among people of this age group. It is interesting to note that in four of our five cases the lesions were near the ankle, and that in the twelve cases reported by Benedict the lesions involved the tibia in eight, the foot in three, and the femur in one. It is possible, therefore, that the less fficient circulation in the lower end of the leg, particularly in people past middle age, and in scarred regions may weaken the resistance to irritation and predispose these regions to malignant change.

In the case in which both sarcoma and carcinoma were found, the reasons for this association and its significance are not known. Once the tendency to malignancy is present, the change is easily accomplished. It may be that the factor which produced irritation of the skin also irritated the bone and each reacted to produce malignancy. In this case, no external manifestation of new growth was evident. This patient complained of pain in the ankle and bleeding from the craterlike lesion in the tibia. For many years, he had had a stiff ankle with a draining sinus nearby, but the function of the leg had been good and he had had no trouble in getting around to do his work.

It is evident then that every effort should be made to induce healing of draining sinuses. It seems likely that the advent in recent years of more effective technical operative measures, followed by treatment such as the Orr treatment and the use of maggots and their extracts, undoubtedly will result in a lessening of prolonged drainage and subsequent

malignancy. All sinuses having a foul odor and those in which hemorrhage occurs and pain comes on for no apparent reason should be thoroughly curetted and the scrapings examined for evidence of malignant change.

Once the presence of a neoplastic process has been established, amputation should be performed immediately, and followed by postoperative irradiation.

CONCLUSIONS

1. In cases of chronic osteomyelitis every effort should be made to cause draining sinuses to heal.

2. If malignancy is suspected from the appearance of a mass, foul odor, pain, or hemorrhage, biopsy should be performed at once. If malignancy is found, amputation should be done immediately.

3. It is advisable to follow the amputation by treatment with deep roentgen rays or radium.

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THE EFFECT OF LARGE DOSES OF X-RAYS ON THE GROWTH OF YOUNG BONE*

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Since the discovery of the roentgen ray, many studies have been made dealing with the influence of this ray upon the growth of various tissues. It was soon found that exposure of growing bone to appreciable doses of the roentgen ray resulted in retarded growth and permanent stunting. In 1933, Brooks and Hillstrom[1] published the results of an extensive investigation of this problem.

In a previous study[2], we not only found that exposure to x-rays retards the growth of young dog bone, but also that this inhibition of growth is accompanied by a marked diminution in the phosphatase activity of the bone. It has not been determined whether this reduction of enzyme activity is an important factor in the retardation of growth. In another experiment [3], it was found that exposure of the entire bodies of young rabbits to 1,100 roentgens resulted in a diminution in phosphatase activity of the entire animal as well as a decrease in body weight.

The object of the present study was to determine: (1) whether bone growth could be completely stopped by x-rays without destruction of the tissues; (2) if complete inhibition occurred, whether any degree of renewed growth took place before maturity of the skeleton; (3) whether, by careful measurements, evidence of any influence on the growth of untreated homologous bones of the same animal could be detected.

The plan of the experiment was to treat one foreleg of each of a large group of uniform animals with a heavy dose of x-rays, and to follow up to adult life the growth of both forelegs of these and a similar group of control animals by measurements of roentgenograms, made at regular intervals under standardized conditions.

PROCEDURE

A group of fourteen pedigreed, New Zealand white rabbits, twenty-five days old, were carefully selected. This group consisted of four small litters. Part of each litter was put in the experimental group and part in the control. Each animal was given an individual mark and its identity was maintained throughout the experiment. There were eight animals in the experimental group and six in the control.

Each of the experimental animals was treated with 2,600 roentgens

* Presented in part before the American Academy of Orthopaedic Surgeons, New York, N. Y., January 15, 1935.

THE EFFECT OF A LARGE DOSE OF X-RAYS ON THE GROWTH OF RABBIT BONE (ANIMAL H_3X_1)

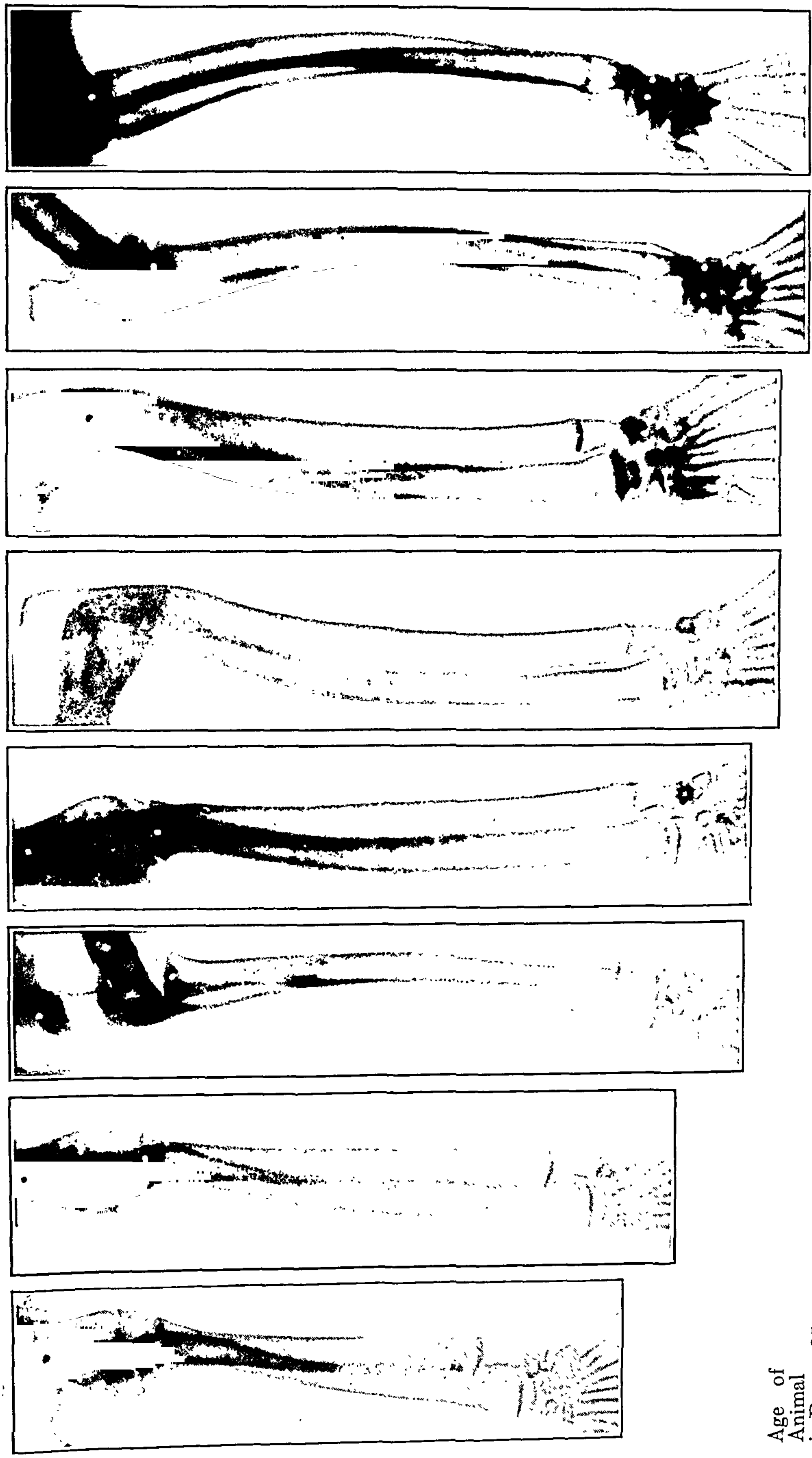

FIG. 1-A

Serial roentgenograms of right foreleg, untreated.

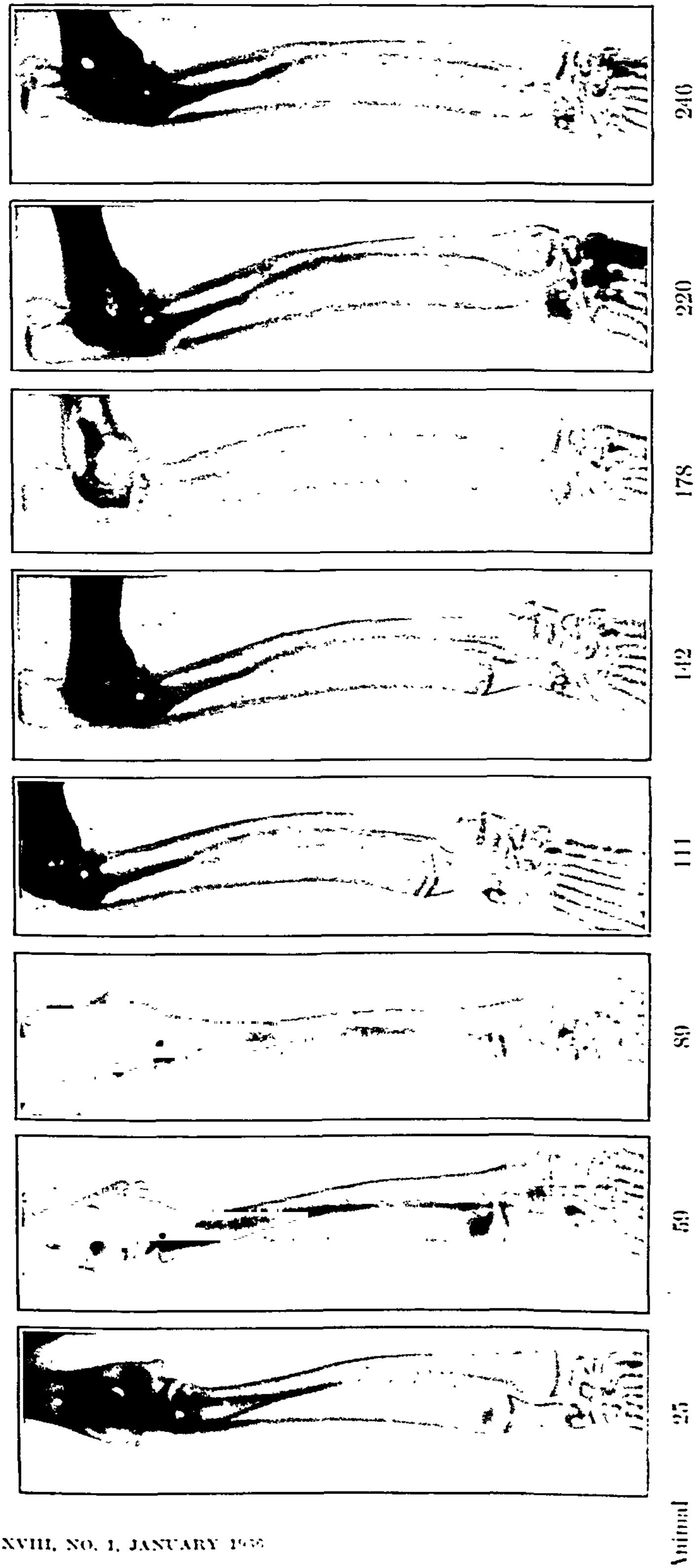

FIG. 1-B

Serial roentgenograms of left foreleg, treated with 2,600 roentgens at age of twenty-five days.

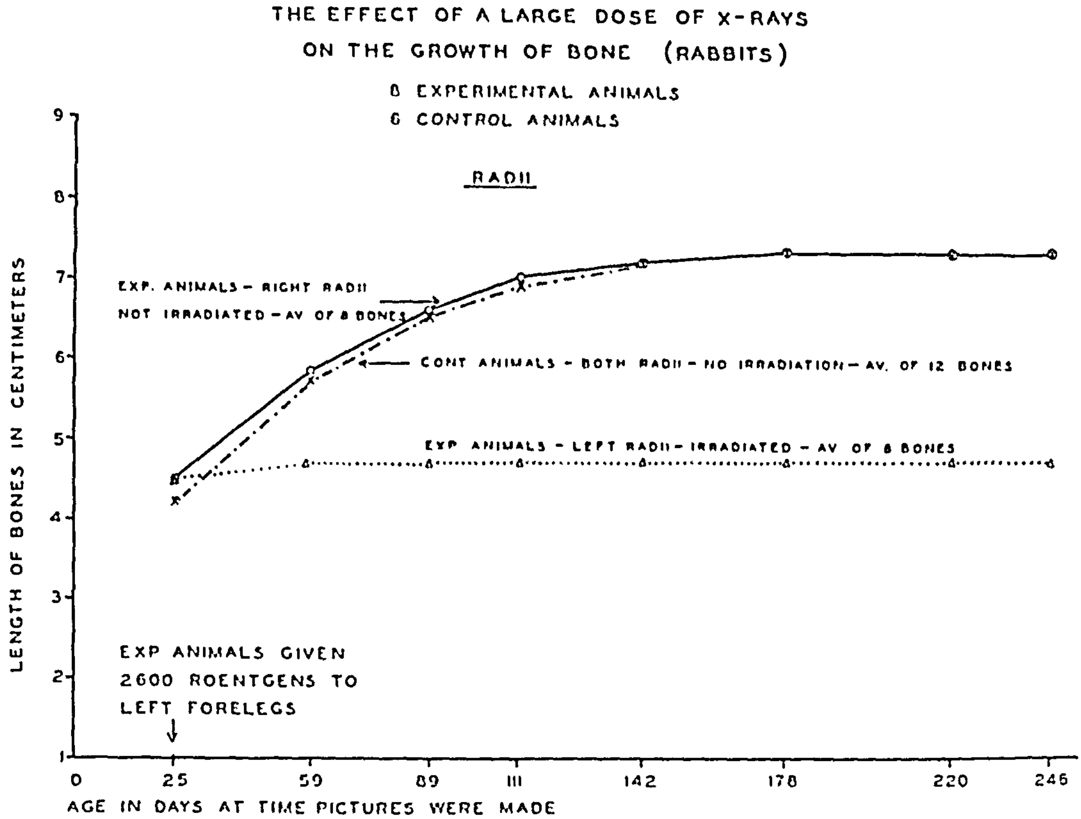

Fig. 2

Curves plotted from measurements of the radii of: (1) untreated forelegs of experimental animals; (2) treated forelegs of experimental animals; (3) both forelegs of control animals. Each point on each curve represents the average value of all measurements of that group of bones made on day indicated.

over the left foreleg, including the lower half of the humerus and the entire foot. The remainder of the animal was completely protected with heavy sheet lead. As an additional precaution, a roentgen meter was placed at different positions within the shielded area and showed no measurable leakage of radiation to the protected part of the animal's body. All treatments were given on the same day. The dosage of 2,600 roentgens was given under the following conditions:

200 kilovolts
20 milliamperes
60-centimeter target-skin distance
1.0 millimeter of aluminum and 0.5 millimeter of copper filter
80 minutes' exposure.

Immediately following the treatment of the experimental animals, roentgenograms were taken of both forelegs of each of the animals, both experimental and control. These roentgenograms were followed by others at intervals of approximately one month, until three consecutive roentgenograms showed that growth had ceased in the control bones. Very careful technique was employed in making the pictures for the purpose of accurate measurements, special care being taken to make all the exposures under strictly uniform conditions. In each case, the animal was

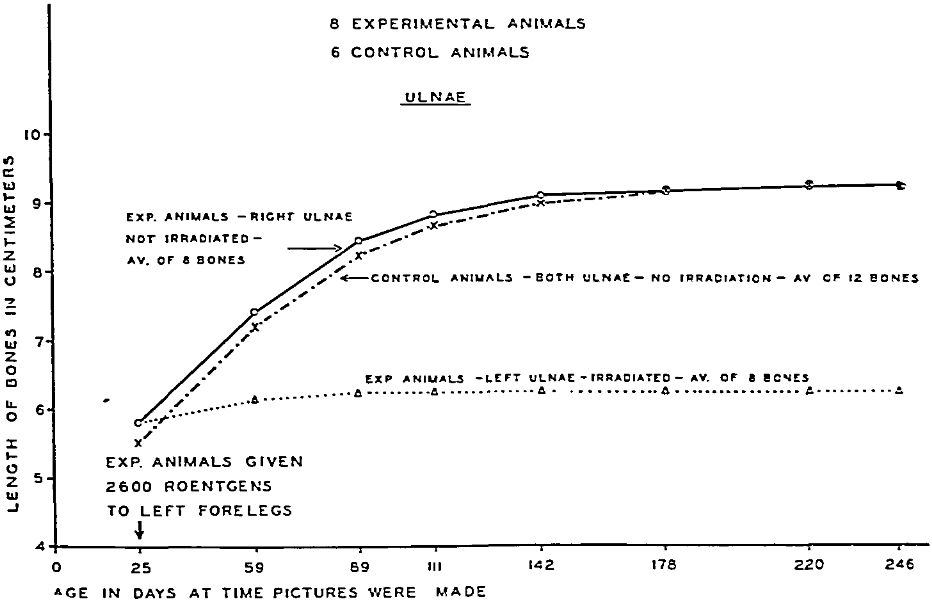

FIG. 3

Curves plotted from measurements of the ulnae of: (1) untreated forelegs of experimental animals; (2) treated forelegs of experimental animals; (3) both forelegs of control animals. Each point on each curve represents the average value of all measurements of that group of bones made on day indicated.

held by two assistants and the roentgenogram included both forelegs. Both elbows and wrists were kept in firm contact with the cassette, and a constant target-film distance (forty inches) was used for all exposures.

In preparing for the measurements, each film was placed over a small viewing box and a pinhole was made in the film at the ends of each bone image. Points of dividers were placed in these holes and the measurements were made on a celluloid millimeter scale.

One hundred and four exposures were

FIG. 4

Front view of the forelegs of one animal, taken eight months after the left leg had been treated with 2,600 roentgens.

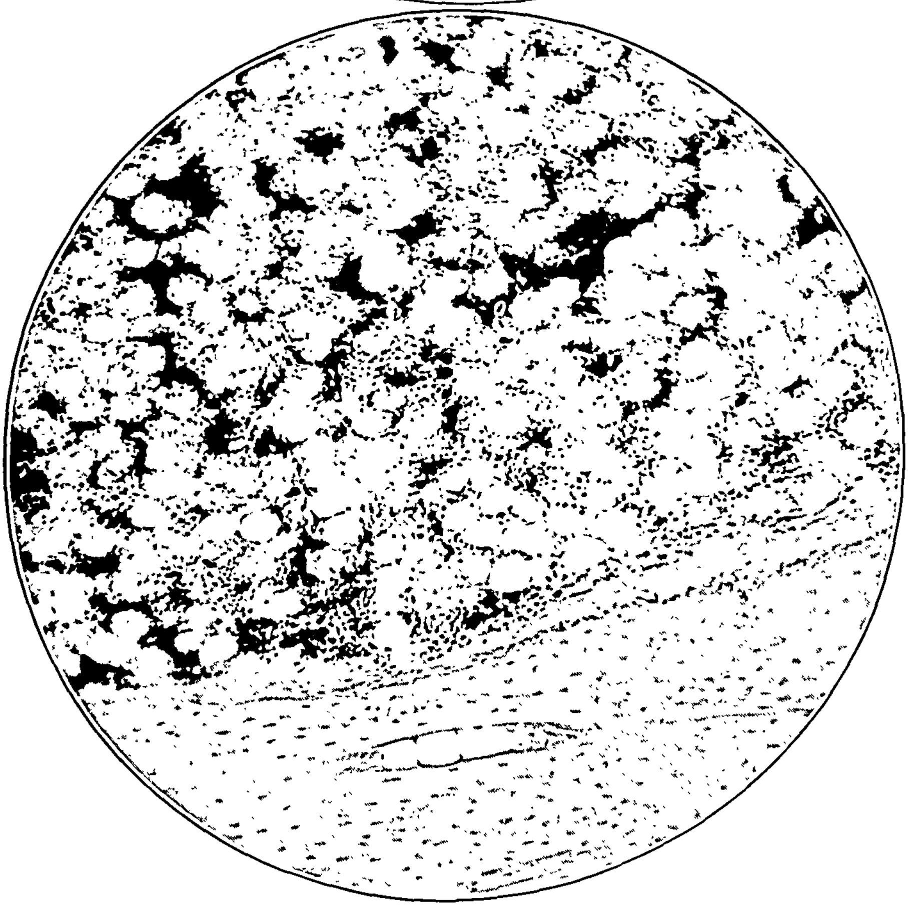

FIG. 5-A
Photomicrograph of right ulna, untreated.

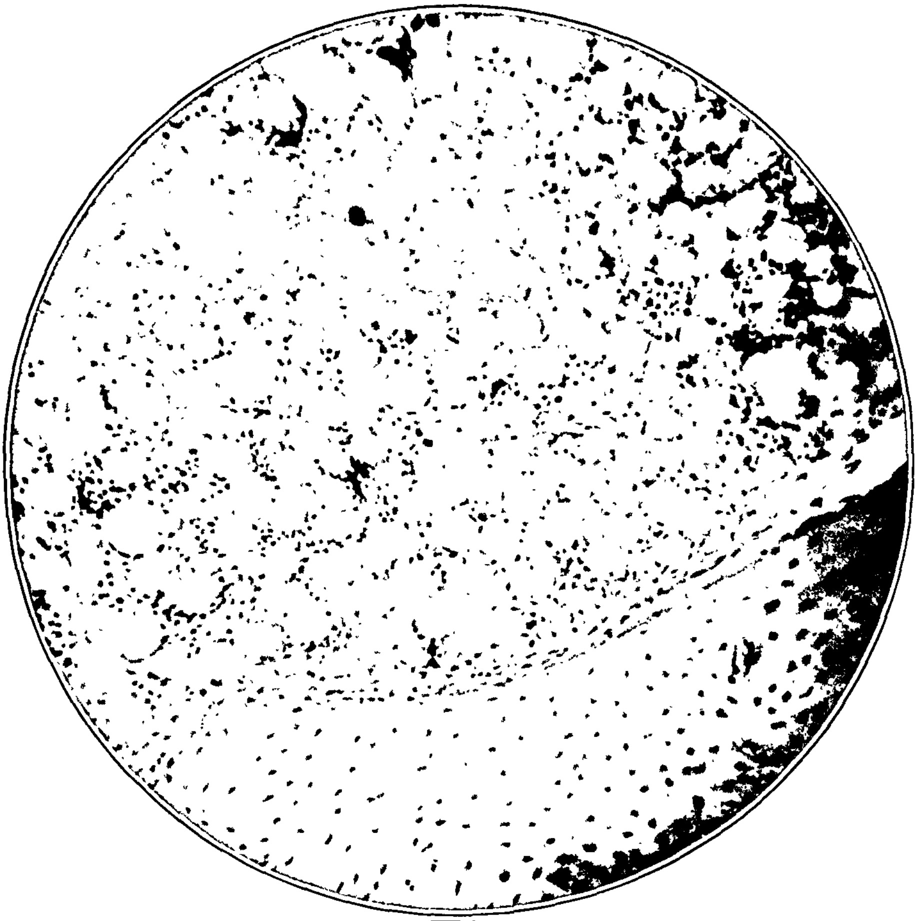

FIG. 5-B
Photomicrograph of left ulna, eight months after treatment with 2,600 roentgens.

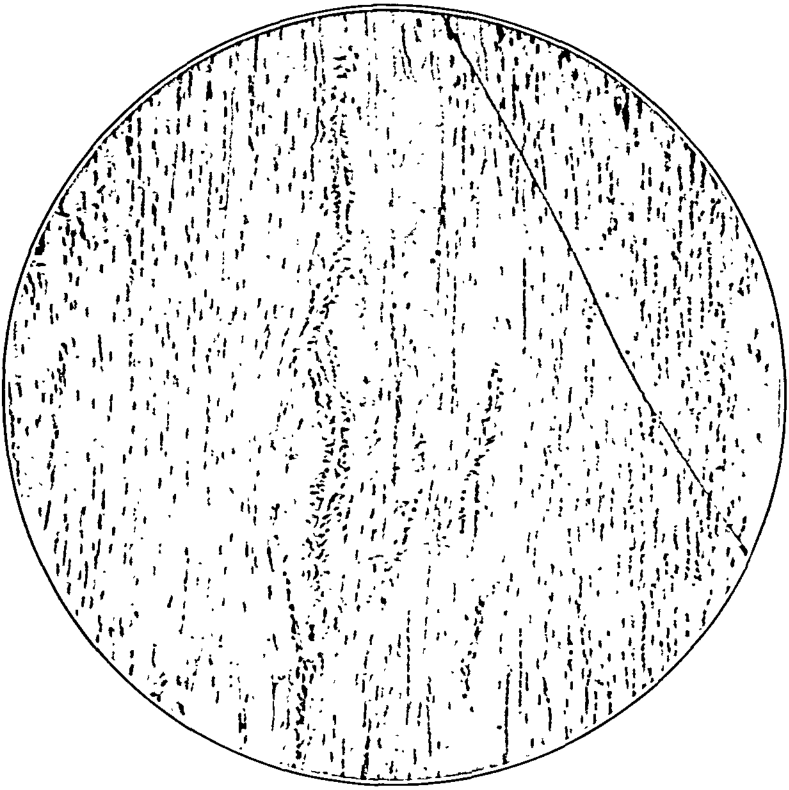

FIG. 5-C
Photomicrograph of skeletal muscle from left foreleg, eight months after treatment with 2,600 roentgens.

obtained, representing 416 pictures of the individual bones. In forty-seven instances, it was impossible to determine definitely from the film the position of the end of the bones; thus, 369 actual measurements were recorded. A typical series of roentgenograms of the bones of both forelegs of one of the experimental animals is given in Figure 1. The position of the pinholes may be seen in some cases.

The results of the measurements of the radii are shown by curves in Figure 2, those of the ulnae in Figure 3. For purposes of comparison, the bones were divided into six groups, three groups each for the radii and the ulnae. The values for homologous bones of the control animals are plotted in a single curve. Those for the right and left forelegs of the experimental animals are of course plotted separately, since the left side was treated and the right untreated. At the time of irradiation, the bones of the experimental animals were slightly longer than those of the controls, since the larger animals of each litter were purposely chosen for treatment.

In every case, the treated forelegs showed evidence of x-ray burns to the skin with loss of hair and slight ulceration. The latter, however, healed promptly and the hair reappeared in a few months. A picture of one of the treated animals (Fig. 4), taken at the termination of the experi-

ment, is given to show the contrast between the two forelegs. Most of the hair was clipped from both legs to show more clearly the difference in size.

Sometime during the first thirty-four days following treatment, the irradiated bones increased very slightly in length. During the next interval between observations, the ulnae showed an extremely slight increase in length, which is almost within the error of the method of measurement. Following this, none of the treated bones showed any measurable growth. This held for the individual bones as well as for the averages. These findings show quite definitely that bone growth, as judged by length, can be completely stopped by exposure to a sufficient dose of x-rays, and that up to maturity of the skeleton no reappearance of growth occurs.

A difference in length persisted for several months between the bones of the control animals and the untreated bones of the experimental animals. During this time the control bones gradually gained on the untreated bones of the experimental animals until they finally became of equal length. Thus it appears that there is no generalized effect on the untreated bones in the experimental animals, as judged by the growth of the homologous bones of the opposite side.

After the last roentgenograms were made, several of the treated animals were sacrificed and the tissues of the forelegs were carefully examined. The gross appearance of the muscles and bones seemed to be normal. Microscopic sections were made of the normal and treated bones and the treated muscles. Photomicrographs of these are shown in Figure 5. These are included to show the condition of the tissues at the end of the experiment.

SUMMARY

Eight of a group of fourteen pure-bred young rabbits of the same age were treated over the left forelegs with 2,600 roentgens; the remaining six animals were used as controls. Roentgenograms of both forelegs of each animal were made at monthly intervals until growth in the controls had ceased. Growth in the radii and ulnae was followed by careful measurement of the roentgenograms for a period of eight months, giving a total of 369 observations. Sometime within the first month, growth in the treated bones stopped completely and did not reappear during the period of observation. Growth in the untreated bones of the experimental animals was not affected.

Part of the expense of this investigation, as well as of the experimental work described in the paper which follows, was borne by a grant from the Division of Medical Sciences of the Rockefeller Foundation.

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THE INFLUENCE OF ROENTGEN IRRADIATION ON THE RATE OF HEALING OF FRACTURES AND THE PHOSPHATASE ACTIVITY OF THE CALLUS OF ADULT BONE *

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Within a few years after the discovery of the roentgen ray, it was learned that exposure of growing bone to this ray results in a decrease in rate of growth. Not only is this true, but also the bone is permanently stunted, never attaining the length and weight that it would normally have reached. Within certain limits there is some degree of correspondence between the quantity of irradiation and the effect produced. In the preceding paper, it was found that exposure to 2,600 roentgens completely stops growth of young rabbit bone as judged by length. Brooks and Hillstrom[1] have recently made a study of the effect of x-ray irradiation on the bones of dogs and rabbits under various conditions. They suggest that the mechanisms of growth and repair of bone may be quite different and thus not show the same reaction to x-ray irradiation. Some authors have suggested a stimulating effect on healing of fractures as a result of mild x-ray therapy. Within recent years, various other factors have been studied for their effect upon the healing of fractures. With doses within the clinical range, Brooks and Hillstrom could detect no changes in the repair of experimental fractures in rabbits when they were treated with x-rays *after* the fractures had been produced. The x-ray treatment was given from one hour to sixteen days following production of the fractures.

In a previous study[7], we found that the phosphatase activity of growing dog bone was markedly reduced following moderate doses of x-rays, the decrease beginning a few days after treatment. This activity reached the minimum value within about a week, and showed a distinct tendency to go up again within four to five weeks. Had the animals been permitted to live to maturity and had roentgenograms been made at regular intervals, it seems possible that the period of the greatest retardation in growth might correspond to the period of minimum phosphatase activity. This study suggested the possibility of a similar effect on the regeneration of bone. McKeown and Ostergren[2], Kamada[3], and the authors[8] have recently made phosphatase studies on fractured bones. Each investigator has reported an increase in phosphatase activity following fracture. McKeown and Ostergren believe that the increase is not confined to the fractured bones, but is somewhat generalized.

* Presented in part before the American Academy of Orthopaedic Surgeons, New York, N. Y., January 15, 1935.

The purpose of the present study was, first, to determine the effect of x-ray irradiation on the healing of fractures in adult bone by following the appearance of the fractures in roentgenograms made at regular intervals; second, to follow the course of the phosphatase activity of these bones at the site of fracture throughout the period of healing.

As a preliminary to the study of fractures, we treated the left forelegs of ten adult rabbits of the same pedigreed stock with 1,100 roentgens and sacrificed these animals at intervals up to sixty days. Phosphatase studies were made on the radii and ulnae. The findings are shown in Figure 1. It is quite clear that the phosphatase activity dropped off gradually, reaching a minimum value about three weeks after irradiation, and went up again within sixty days.

EFFECT OF X-RAYS ON PHOSPHATASE ACTIVITY OF ADULT RABBIT BONES

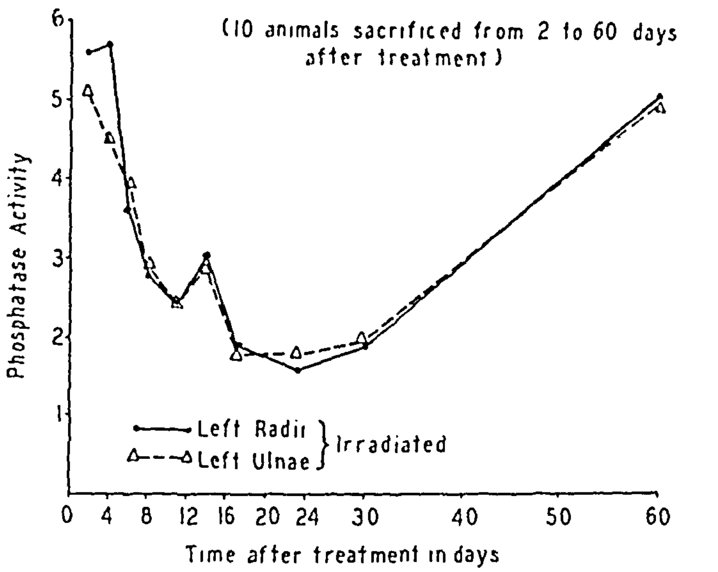

Fig. 1

We wished to produce fractures in a group of animals at a time when the phosphatase activity would be at a minimum and continue low for several weeks after fracture. In order to accomplish this, we treated eight adult female rabbits over the left forelegs with 1,112 and 622 roentgens* two weeks and one day, respectively, before producing fractures. On the basis of the previous findings shown in Figure 1, this treatment would maintain a low phosphatase activity in unfractured bones for at least four to five weeks. On the day after the second x-ray treatment, comminuted fractures were produced in both the experimental (irradiated) and control (unirradiated) ulnae of these eight rabbits, as well as in both ulnae of four control (unirradiated) animals. This was done by open operation in the manner described in a previous study [8]. The right ulnae of the treated animals, which had not been irradiated, were used as "semi-controls" and both ulnae of the four "control" animals were considered as "complete controls". Complete controls were used in order to detect any possible generalized effect of the irradiation on the factors under consideration. Roentgenograms were made

* The factors constituting the first dose (1,112 *r*) were: 200 kilovolts, 20 milliamperes, 60-centimeter target-skin distance, 0.25 millimeter of copper filter, and 20 minutes' exposure. The factors constituting the second dose (622 *r*) were the same as those given above, with the exception that the filter consisted of 1.0 millimeter of aluminum and 0.5 millimeter of copper.

of both forelegs of all twelve animals once each week. Eighty-eight pictures were taken, both forelegs of each animal being included on the same film. Thus, 176 observations were recorded, including two to fifteen pictures of each fracture. Throughout the period of observation all of the animals were kept under standard conditions at the registered rabbitry from which they were bought. The experimental animals were sacrificed at intervals of one to three weeks and the controls at intervals of two to six weeks. The bones were removed whole, carefully freed from soft tissue, and examined for size of callus and mobility. Sections, three centimeters in length and including the fractures, were then removed and weighed. These were cut into small pieces and extracted for seventy-two hours with twenty-five parts of water to which a few drops of chloroform had been added as a preservative. Phosphatase determinations were made on the filtrate from this material as described in a previous report [7].

Upon examination of the roentgenograms, a typical series of which is reproduced in Figures 2-A and 2-B, it was clear that there was in each case a marked delay in healing of the fractures in the irradiated ulnae as compared with the control bones. Figures 2-A and 2-B show the fracture in the control bone united after twenty-four days, whereas the fracture in the irradiated bone did not show union until the sixty-sixth day. A similar delay was present in each of the experimental animals. In one of the experimental animals, that shown in Figures 3-A and 3-B, the fracture in the control bone was united after thirty-eight days, while the fracture in the treated bone was still ununited when the animal was sacrificed on the 101st day. This marked delay suggests a possible permanent non-union.

Figures 4-A and 4-B show the progress of healing of the fractures in both ulnae of a typical control animal. It is clear that union progressed uniformly and was complete in both bones after thirty-one to thirty-eight days.

Examination of the bones after removal from the body and after cleaning showed that rigidity in both the semi-control and complete-control ulnae was attained well before that of the irradiated bones. By inspection also, the callus of the fractures in the experimental ulnae was in general found to be smaller than that of the fractures in the control ulnae, regardless of the time.

The values for phosphatase activity are given in Figure 5. In both the semi-control and complete-control bones, it is quite evident that the amount, or at least the activity, of this enzyme was greatly increased in the region of the fracture as compared with normal unfractured bone, reaching a high level within the first week after fracture before the appearance of any hard callous material. This is in agreement with a recent study[8] by the authors. The irradiated bones also showed an increase in phosphatase activity in the region of the fracture, but it is quite evident that this increase was not nearly as marked as that in the unirradiated bones. While the dose of x-rays employed reduces the phosphatase activity of bone, it is clear that it does not completely inhibit the increase

DELAYED UNION OF FRACTURE IN ADULT RABBIT FOLLOWING DEEP X-RAY TREATMENT (ANIMAL E-5)

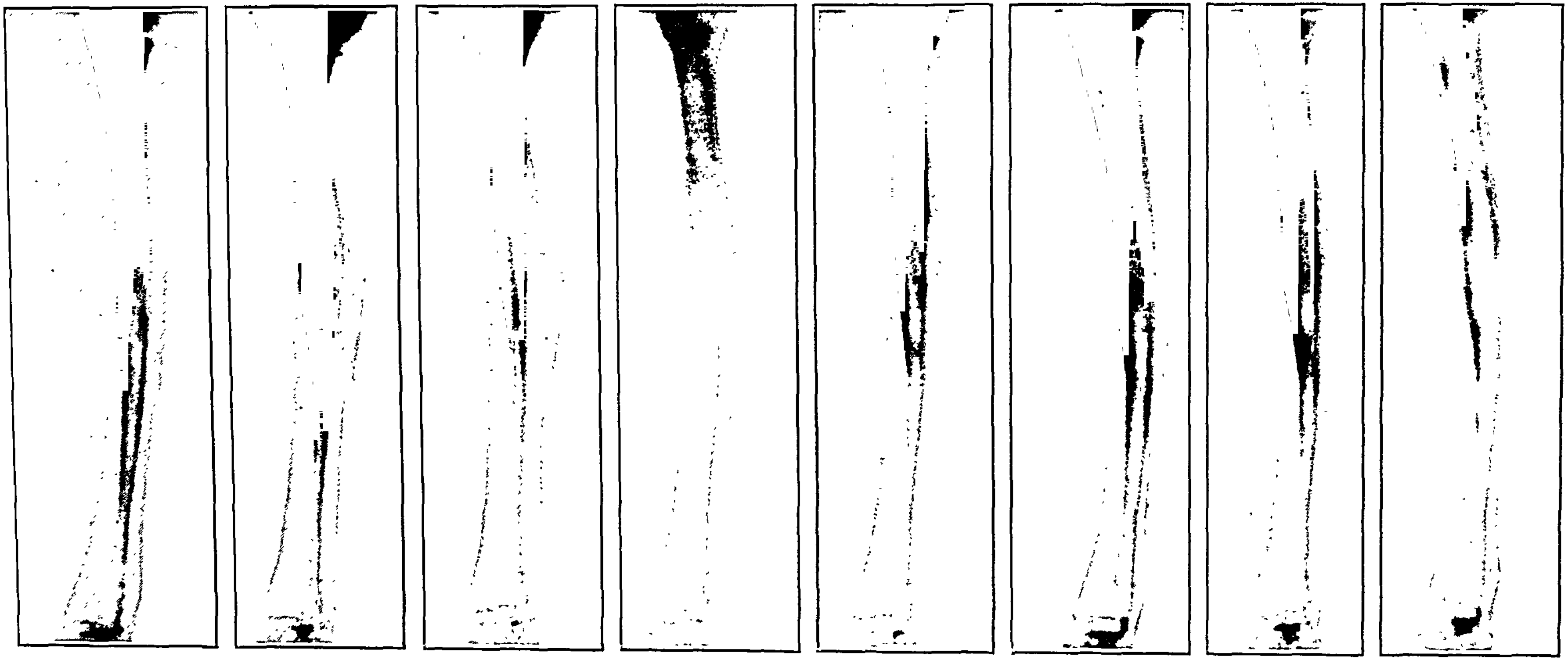

FIG. 2-A
Serial roentgenograms of right foreleg. Ulna fractured. No x-ray treatment.

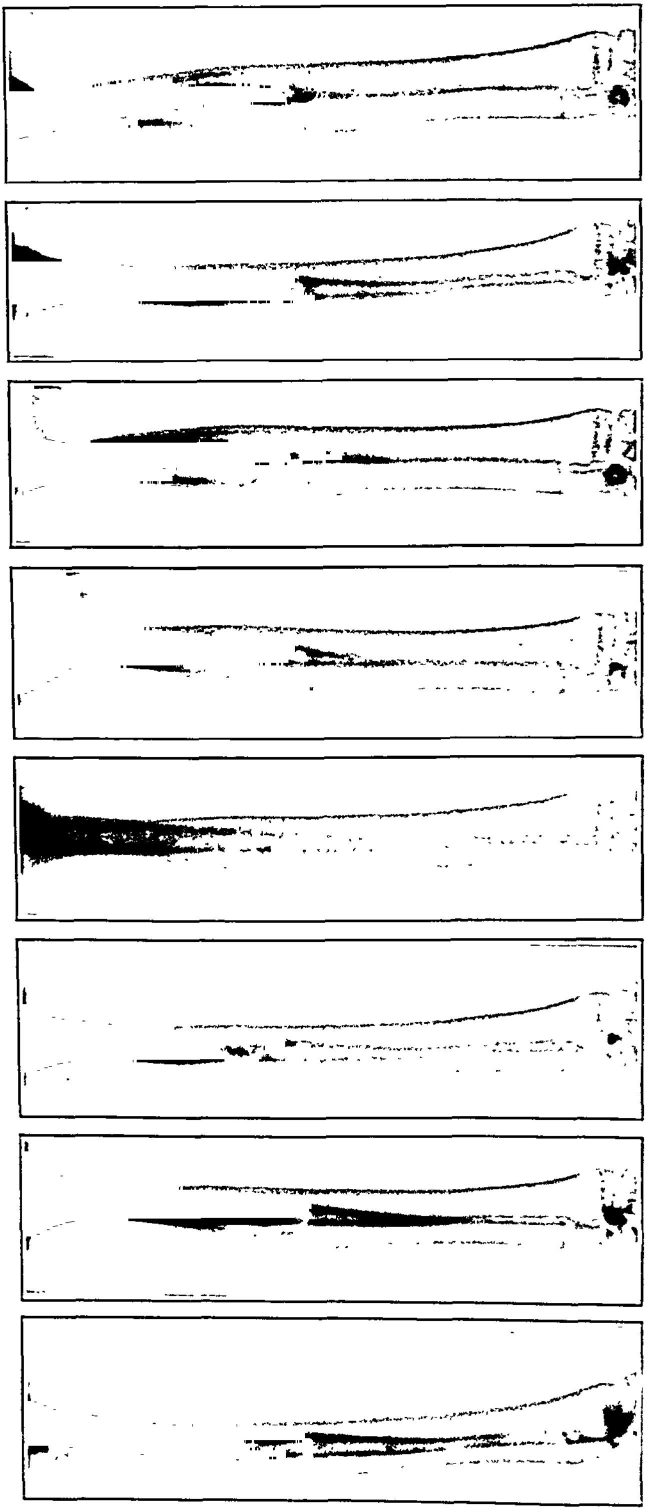

Fig. 2-B

Serial roentgenograms of left foreleg. Ulna fractured. Treated with 1,734 roentgens.

DELAYED UNION OF FRACTURE IN ADULT RABBIT FOLLOWING DEEP X-RAY TREATMENT (ANIMAL E-6)

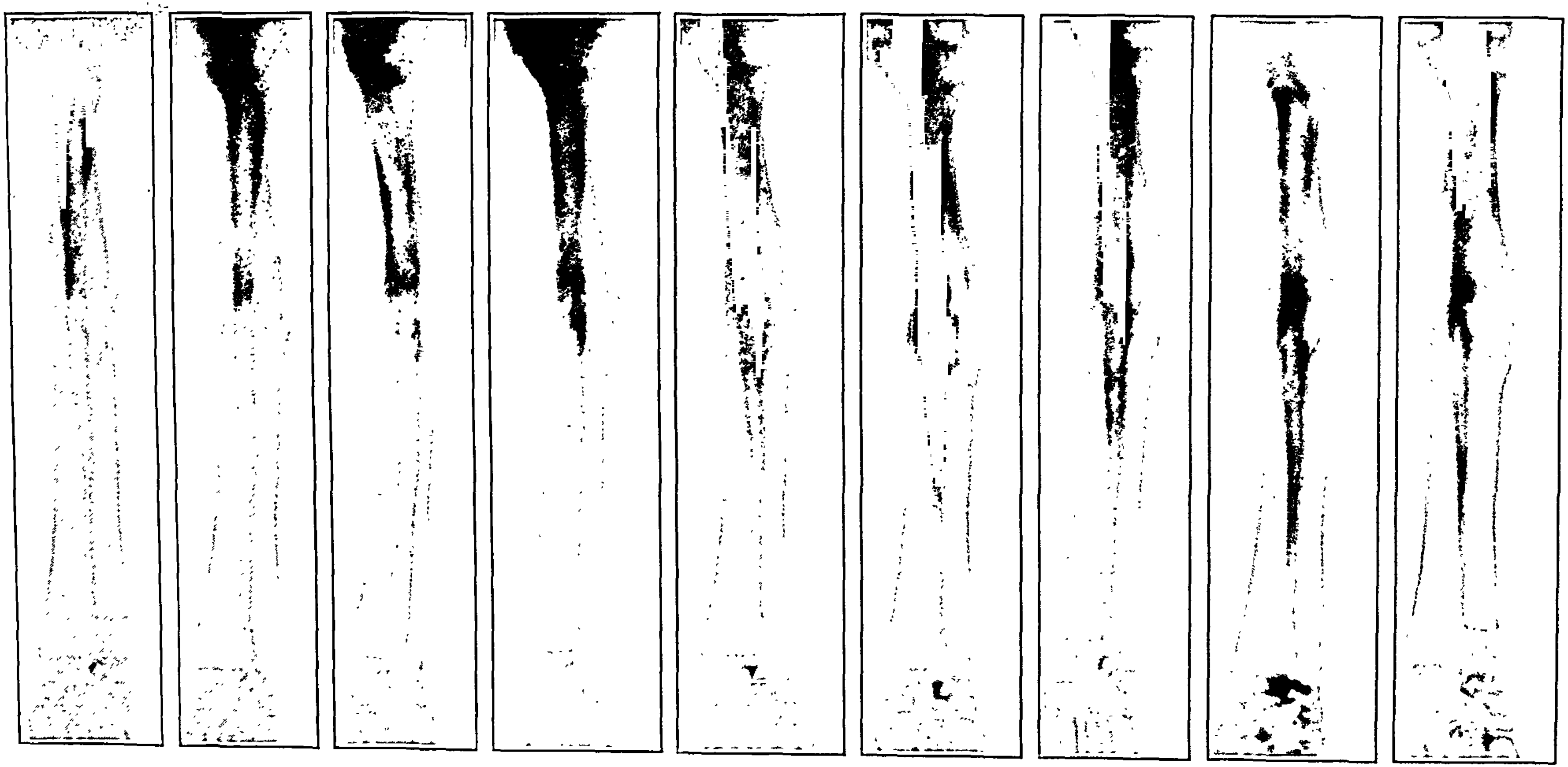

FIG. 3-A
Serial roentgenograms of right foreleg. Ulna fractured. No x-ray treatment.

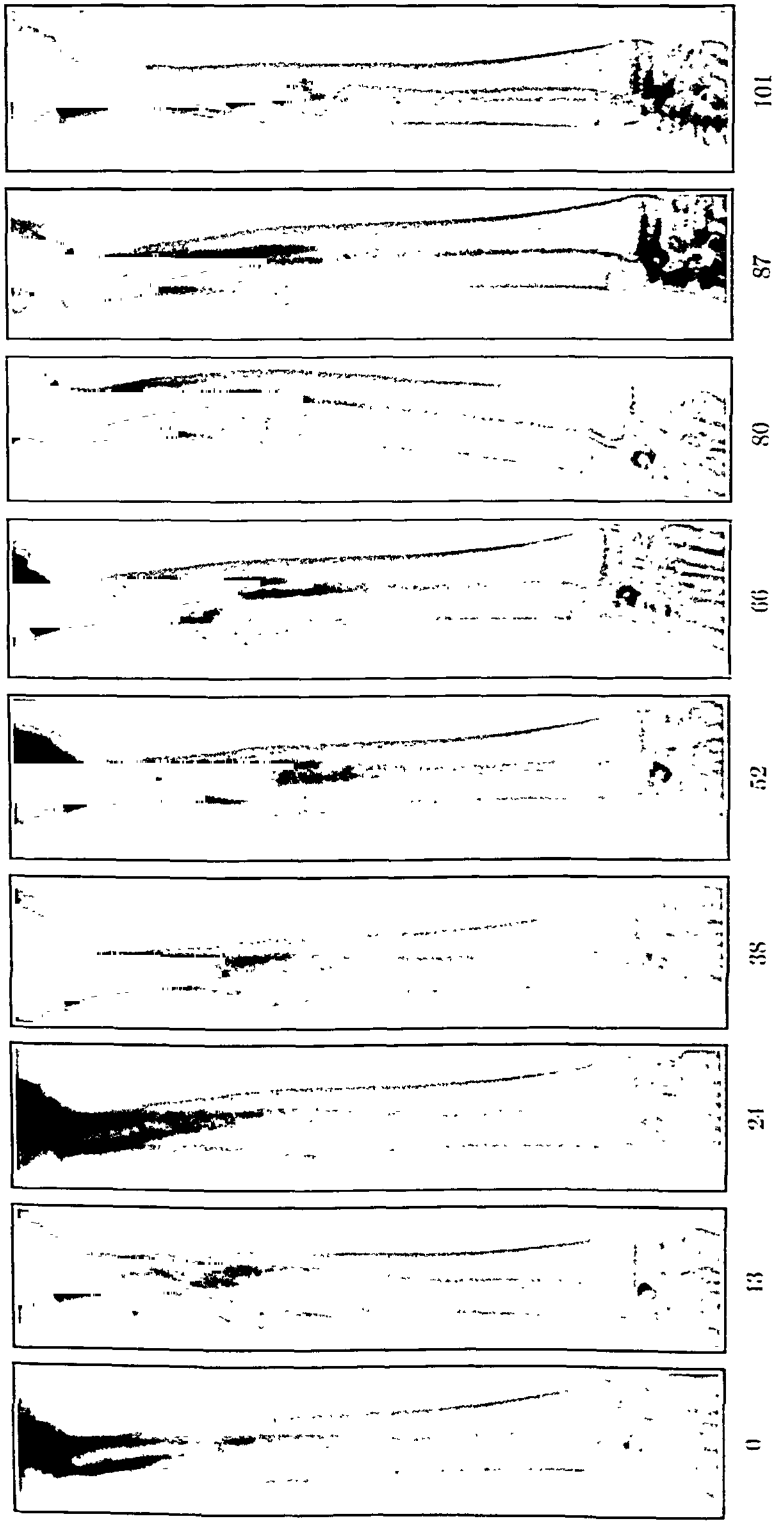

FIG. 3-B

Serial roentgenograms of left foreleg. Ulna fractured. Treated with 1,731 roentgens.

HEALING OF FRACTURE OF BOTH ULNAE OF ADULT RABBIT (ANIMAL E-11)

Days
ter Fracture 0 6 13 20 24 31 38 45

FIG. 4-A
Serial roentgenograms of right foreleg. Ulna fractured. No x-ray treatment.

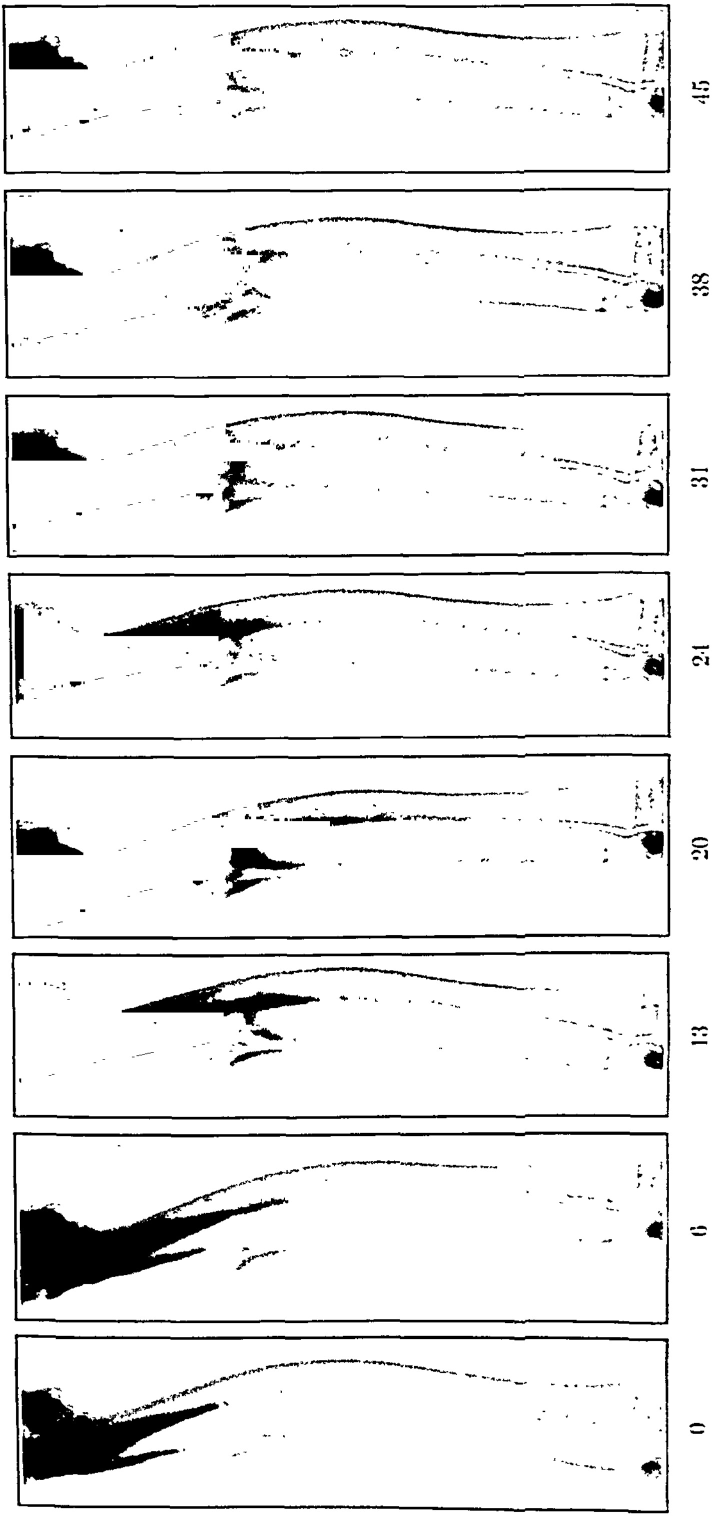

FIG. 4-B

Serial roentgenograms of left foreleg. Ulna fractured. No x-ray treatment.

in the enzyme that normally occurs in the healing of fractures. Thus, the fracture tends to increase greatly the phosphatase activity, while x-ray irradiation tends to inhibit this increase. By comparison of the roentgenograms with the phosphatase values, it is noted that the highest enzyme activity occurred within the period during which the first evidences of union were detected. This relationship lends further support to Robison's[4,5,6] theory regarding the rôle of phosphatase in ossification.

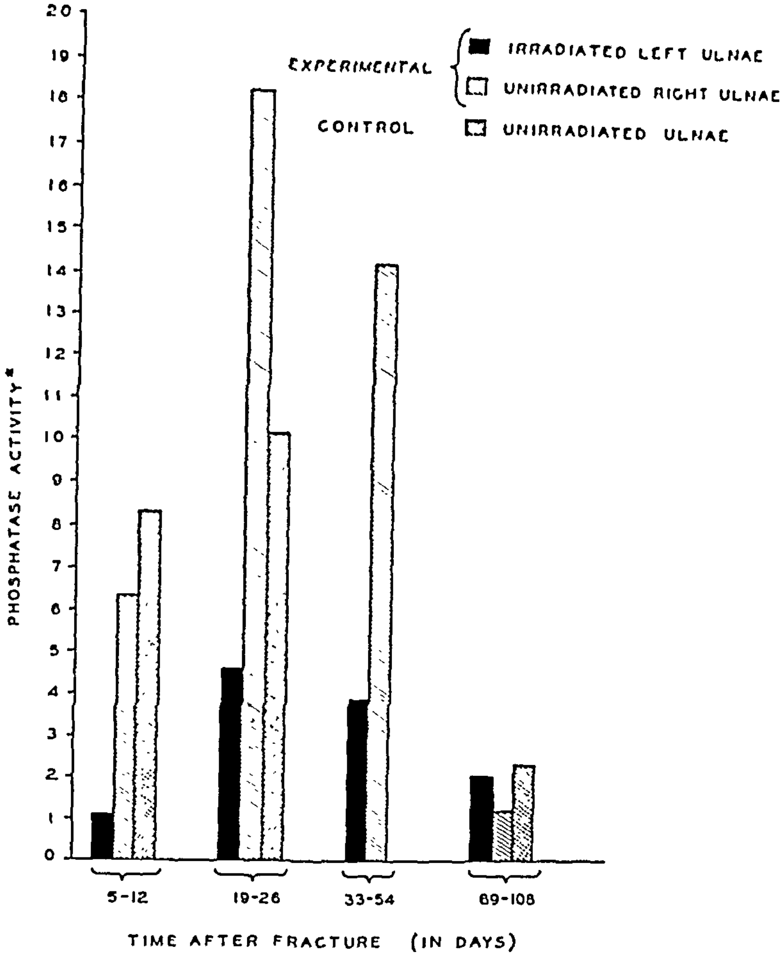

Fig. 5

The course of the phosphatase activity at the site of fracture of normal and irradiated bones.

* The phosphatase activity is expressed as the number of milligrams of inorganic phosphorus liberated per hour by the enzyme contained in the entire water extract of the sample from a substrate of sodium-Beta-glycerol-phosphate buffered with glycine-NaOH, at a pH of 8.8 and a temperature of 38 degrees, centigrade. The activity of the enzyme is calculated on the basis of the entire water extract rather than per unit of volume, since this is a better index of the amount of phosphatase present in the healing tissues.

A series of experiments similar to the foregoing is being carried out on seven litters of young rabbits, using litter-mate controls. The findings to date are essentially the same as those in the adult animals, with the exception that the fractures in both irradiated and untreated bones are healing more quickly than the corresponding groups in the adult series.

This, of course, is in agreement with clinical observations on the healing of fractures in children and adults.

CONCLUSION

Moderate doses of x-rays given previous to the production of fracture in adult rabbit bone result in marked delay of union and inhibition of the rise in phosphatase activity that normally accompanies the healing of a fracture.

NOTE: The possible clinical applications of the findings reported in these two papers is now being investigated. The results of this study will be given in a subsequent report.

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PREVENTION OF DEFORMITY IN ARTHRITIS*

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It is generally recognized that chronic arthritis is a constitutional disease, and that its treatment requires a great deal of concentrated care and study, in cooperation with the internist. From the point of view of orthopaedic surgery, we are primarily interested in seeing to what extent deformity can be prevented and how far the patient can be restored to a functionally useful life. In considering this problem, certain facts are accepted:

1. Deformity can be prevented;
2. Treatment requires time;
3. The result of after-care is the real test of orthopaedic success;
4. The postarthritic use of the body determines the future welfare of the impaired joint;
5. The freedom from recurrence depends on the health of the body and the lack of strain to the joint.

The question is: Can we by orthopaedic means return these patients to an active life, either well or restored to comparative usefulness? The author believes that the answer to this question is in the affirmative, provided that certain requirements can be fulfilled,—namely, early adequate treatment, cooperation between the medical and orthopaedic departments, cooperation of the patient, and conscientious follow-up. This last factor is as vitally important as early care. Many patients can be restored to functional activity, but they become careless and slip back because of their own neglect. It is the writer's belief that most of the serious deformities in arthritis are unnecessary if these desiderata can be secured. The final test of our work is the ability of the patient to live and work and move. During the months of treatment, we must be constantly preparing for the time when walking and the erect posture can be resumed.

It is not within the province of this paper to go into the details of how to make splints or to repeat the ground covered in the literature[1, 2], although the methods of prevention are constantly improving, both from the non-operative and operative standpoints. It seems more important that emphasis be placed on the principles of prevention, so that each surgeon may work out his own method.

PREVENTION OF DEFORMITY

In the first place, most arthritic deformities are flexion deformities, resulting primarily from the necessity for muscular protection of a sore joint. Therefore, the time to prevent the deformity is before chronic

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spasm and contraction of the muscles have taken place and flexion has begun. The only way to prevent pain and muscle spasm and to secure rest is through fixation of a joint, the same principle which is carried out in the treatment of fractures.

There has been a superstition among laymen that one should "keep going"; that the joints should be moved in order to keep them from getting stiff. However, use of the joints is not permitted in any other inflammatory disease. Rest, then, is the first requirement for an inflamed joint, since it reduces pain and inflammation through removal of trauma, and with it the necessity for protective muscle spasm, and it effectively prevents flexion deformity of the joints. The best way to produce rest is by plaster casts applied to the extremities in such a way as to secure the best position for future use.

There is one factor which the writer feels is not sufficiently appreciated by most orthopaedic surgeons in treating arthritic joints,—namely, the fear which a sore joint produces in the mind of the patient, a mental complex of fear which overrules almost all other areas in life while it is present. The pain of a jar or motion in an inflamed joint is excruciating. It is not easily forgotten, and is partly responsible for many of the deformities. If this mental complex can be broken up by the knowledge that the jar and motion cannot occur after a cast has been applied, the patient relaxes all over and the process of building up is started. The elimination of fear gives that relaxation of mind which is exemplified many times by the confidence which the patients have in certain nurses and doctors.

The next point is: How long should these casts be used? It seems that the inflammation abates quicker with rest than it does without. The more complete the rest, the quicker the subsidence of the inflammation. Experience teaches that the slight traumata of use and motion do keep up the active arthritis. It has been the experience of most who have used protective splints in arthritis, both in this country and abroad, that it does no harm to keep a joint perfectly quiet in plaster anywhere from two to seven days. There is no danger of fibrous adhesions and permanent stiffness during this length of time. However, it is safe to make the rule that the cast be split at the end of two days and the joint inspected and passively moved as far as possible. This plan of daily inspection, daily motion, and observation of the reaction in the joint should be continued until the active inflammation seems to have subsided enough to allow for longer periods of freedom from complete rest. Sometimes this may take days, sometimes weeks. The principle of complete rest from weight-bearing activity should be continued until the time when the joint can be used quite freely. It has been the author's custom to continue the night rest indefinitely, as it eliminates fear of motion during sleep and consequent protective muscle spasm. Freedom from splints during the day allows activity and exercise either by physiotherapy or by occupational therapy. Even without motion of the joints, muscle training can go on. System-

atic education in the control of separate groups of muscles can be given, so that when use is permissible the muscles are already strengthened enough to carry out the desired motions. With this method of protection, adhesions are less apt to form and pannus is less liable to occur.

The use of these plaster casts requires a knowledge of the usual complications in arthritis and the ability to anticipate what is likely to happen. With the institution of this regimen before contractures have taken place, it has been the author's experience that a large number of deformities can be prevented. (See Figures 1 and 2.) It has been possible to cut down the number of operations performed for contraction deformities of the joints and to shorten the stay in the hospital for rheumatoid arthritics from fourteen months to a little over six months.

CORRECTION OF DEFORMITY

Non-Operative Procedure

The next procedure required of the orthopaedic surgeon is the correction of deformity by non-surgical means. It is interesting that the same principle of complete rest of the joint by protection with plaster casts works even when flexion contractures have already begun. Relaxation of the muscles which are causing flexion results in the immediate loosening of the flexion. Therefore, a plaster cast which has been left on a flexed knee for two or three days can be changed to a much straighter cast. In many of the contractions, this process of gradual correction by rest and relaxation is sufficient to overcome the deformity, so that surgical interference is not necessary. The prevention or correction of deformity without operation gives a better functioning joint than by operative measures, although surprisingly perfect results can be obtained by operation.

Manipulation

If, after conscientious use of plaster splints and mechanical stretching by apparatus such as wedge splints and calipers, the joint still continues to have limited motion, due to adhesions, and the deformity cannot be corrected, manipulative procedures are indicated in certain cases in which the arthritis is really quiescent. Manipulation should never be tried, however, during the active stage of the disease. It is well if manipulation can be avoided, because it is very apt to produce trauma and trauma causes more inflammation and a greater limitation of motion. However, in certain selected cases, manipulation of the knee has been quite successful in stretching tight muscles and the capsule and in breaking adhesions. The wrist is often successfully manipulated, as are the shoulders and feet. Manipulation of fingers and hips has not been found as successful as that of the other joints mentioned. Great care should be taken in manipulating the knees to use short leverage because the femur in an atrophic (rheumatoid) arthritic is liable to be easily broken because of the softness of the bones. Manipulation definitely has its place in the treatment of arthritis, but the cases have to be very carefully selected.

December 9, 1931 May 26, 1933 August 23, 1934 April 30, 1935

Fig. 1

A. H., aged 19, weighing 84 pounds, was admitted to Robert B. Brigham Hospital in December 1931, with rheumatoid (atrophic) arthritis of a year's duration. All joints were splinted and rested to prevent pannus formation and deformity while in bed. The disease ran a downhill course until November 1932, when gradual improvement began and continued under general medical care. The patient began walking in May 1933 with a caliper splint for the right knee and crutches. Note the hollow back, bad balance of the pelvis, and droop shoulders,—conditions which, if allowed to continue, would cause strain on the joints. By August 1934, the posture had improved with exercises and braces, and the joints were well enough to permit the supports and crutches to be discarded. There was no active arthritis, but an aeroplane splint was applied to the left shoulder to prevent contraction. In April 1935, the patient weighed 105 pounds; the posture was better; and, with the exception of some ankylosis of the fingers, there was full motion in all joints. The patient has been leading an active home life for a year and a half and there has been no recurrence of the arthritis.

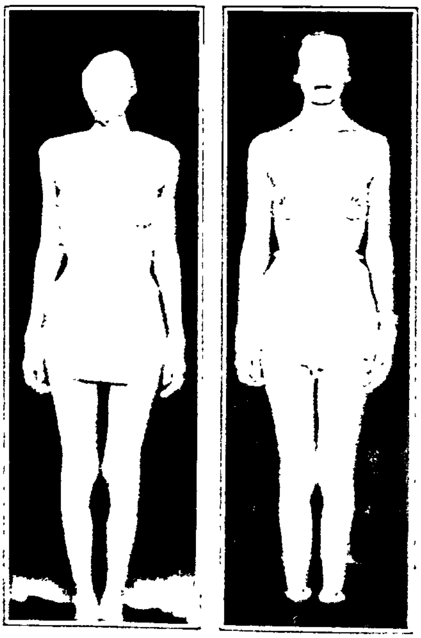

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Fig. 2

A. H., showing general improvement in four years.

Operative Procedures

What are the most successful operations which have been performed in the correction of deformities in arthritis? Operations on arthritic joints are no more hazardous than are those performed on any other type of joint. Apparently, the bones heal as well in arthritis as in other diseases, and there is no more danger of infection in opening an arthritic joint than in any other type of joint. The wounds also heal as easily. The joints which are most successfully operated on are the elbows and knees. (See Figures 3 and 4.) Operations on the shoulder, fingers, and hips have not been as successful.

Although some hands have been reconstructed by doing arthroplasties on the finger joints, really satisfactory hands have not resulted. Arthroplasties on the hip have been successful in but a very small percentage of the cases. The tendency to ankylosis is very great. Arthroplasties on the elbow give satisfactory results in practically all cases. Arthroplasties on the knees are successful in most cases, but there is the possibility of limited motion.

In knees which are flexed and have motion, with the patellae free, the posterior capsuloplasty, as developed by Wilson[3], has given the best results. In such cases, the posterior capsules are tight with adhesions, and the cutting of these adhesions is preferable to manipulation.

Another operation which has been successful in certain selected cases is synovectomy. Where the overgrowth of villous tissue has been considerable, particularly in the suprapatellar pouch around the patella, and where there is a good deal of pannus formation between the femur and tibia, the removal of this tissue permits free, painless motion of the knee. However, the cases have to be carefully selected and the after-care is important in order to prevent adhesions from forming and again restricting motion in the joints. If possible, this operation should not be done in the active stage of the disease.

Arthrodesis is an operation which in certain cases gives a stable knee or hip, making painless use possible. The aim of the orthopaedic surgeon, however, should be to secure motion whenever possible.

There are certain principles to be remembered in operating on arthritic joints. Motion should be started after the operation as soon as the soreness has gone. Therefore, arthritic joints should not be held long in one position. In order to prepare for this early motion, the muscles to be used in flexion or extension of any joint should be developed for a period of time before the operation. This is more important in securing a functionally useful joint than the actual technique of the operation itself. Operations should never be performed during the active stage of the disease.

AFTER-CARE

Strain from poor posture is quite capable of undoing much of the benefit of the preventive work on the knees and feet. Poor posture pro-

January 12, 1928 | May 2, 1928 | April 21, 1932 | April 23, 1935

FIG. 3

L. V., aged 17, weighing 66 pounds, was admitted to Robert B. Brigham Hospital in November 1925, with rheumatoid (atrophic) arthritis of eight years' duration. She was bedridden and unable to stand or move. There was slight motion in the neck, back, right hip, shoulders, and knees; the rest of the joints were apparently fused. The patient's condition was built up by exercise, physiotherapy, and correction of posture and, in June 1927, an arthroplasty was performed on the right elbow. A similar operation was done on the left elbow in September 1927. Perfect functional results were obtained in both cases. In January 1928, the patient weighed 74 pounds and was ambulatory with a splint for the subluxated, outwardly rotated right knee. In November 1928, she weighed 84 pounds, and an arthroplasty was done on the right knee, following which she was able to walk with crutches. Arthroplasties on the third and fourth fingers of the right hand were done in April 1929, followed by an osteotomy of the left hip in September 1929. The patient was discharged walking in February 1930. Since then, there has been no active arthritis and the patient has full use of the elbows, neck, and back. She walks, does some light housework, and comes to the Out-Patient Clinic.

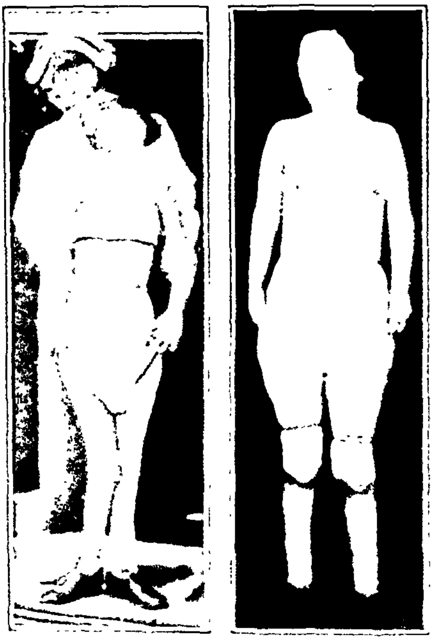

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FIG. 4

L. V., showing general improvement in seven years.

duces undue strain in standing and ultimately causes recurrence of inflammation in the joints which are subjected to this irritation. A lordotic back invariably strains hips and knees. It is important, therefore, to prevent this by careful physical training in the use of the body in bed and in sitting up before walking is allowed. Much time and suffering can be saved, and walking is made easier. Just as careful attention should be paid to the rebalancing and the after-training as is paid to splinting in the active stages of the disease. The future welfare of the patient depends on his learning to walk correctly with the least possible strain on the joints in order to prevent recurrences of inflammation and deformity. The meticulous care which is given during the years following the active arthritis really determines the ultimate success of the treatment. There can be no let-up in medical hygiene, diets, or physical training. Recurrence must be anticipated by warning the patient that he cannot take chances of lowering his vitality in any way.

Recurrences of the active disease and of deformity are too often the results of carelessness on the part of both patients and doctors, and of a reversion to old habits of living. It is the responsibility of the orthopaedic surgeon to be alert to this tendency to slump, and to prevent it. It is only in this way that deformity in arthritis can be prevented.

SUMMARY

1. The usual deformities attendant on arthritis result from flexion and are preventable if treatment by splints is begun early.

2. Correction of deformity is often possible by means of a series of splints.

3. Orthopaedic manipulation is sometimes successful in correcting contraction.

4. Operations such as arthroplastics, posterior capsuloplasties, synovectomies, and arthrodeses can be successfully employed in cases of chronic arthritis.

5. The patient must be so balanced as to posture that future strain will not cause recurrence of joint symptoms.

6. Until the patient is thoroughly trained in how to live, the after-care for several years is perhaps the most important part of the treatment.

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FURTHER STUDIES OF FIXED PARALYTIC PELVIC OBLIQUITY *

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From the Hospital for Joint Diseases

In a previous communication[2], the author stressed the importance of fixation of the pelvis in an oblique position as one of the major paralytic deformities. Depending upon the muscles involved, the obliquity may be divided into two main groups: first, that caused by an imbalance of the abductors and adductors of the thigh; second, that caused by an imbalance of the trunk muscles. The first type is also distinguished from the second by the fact that, when the contracture is limited to the abductors or adductors, the pelvic obliquity can be overcome with the patient in the recumbent position by swinging the legs to one side or the other. If, however, the trunk muscles are responsible for the obliquity (second type), the pelvic tilt persists even in the recumbent position irrespective of the position of the legs. The kinesiological pathology causing the first type of fixed paralytic pelvic obliquity is easy to understand, and its treatment is equally simple. Division of the tight abductor or adductor structures, coupled with a simple fascial transplant, has thus far in a group of carefully followed cases given complete, permanent correction of the pelvic obliquity. The second group, however, represents a far more complicated and difficult problem. It is with these obliquities, due to imbalance of the trunk muscles, that this paper deals. Both in the accurate diagnosis and in the effective treatment, these cases present many unsolved problems which challenge the ingenuity of the orthopaedic surgeon.

Just as in the first group the femur must be thought of as balanced by the opposing action of the abductors and adductors, so in the second group the pelvis must be thought of as balanced by the opposing action of certain trunk muscles, particularly the quadratus lumborum, the obliquus externus abdominis, and the obliquus internus abdominis (Figs. 1 and 3). The sacrospinalis and longissimus dorsi also play a rôle, but, owing to their location close to the midline, their leverage action in causing a tilting of the pelvis is less than that of the muscles lying in a more lateral position. The quadratus lumborum, the obliquus externus abdominis, and the obliquus internus abdominis are powerful flexors of the trunk when the pelvis is held immobile. Conversely, if the dorsal spine and the thorax are held rigid, they tilt the pelvis, an action which can be observed to particular advantage in certain oriental dances. These muscles must, therefore, be reckoned not only as lateral flexors of the trunk, but as lifters of the pelvis.

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

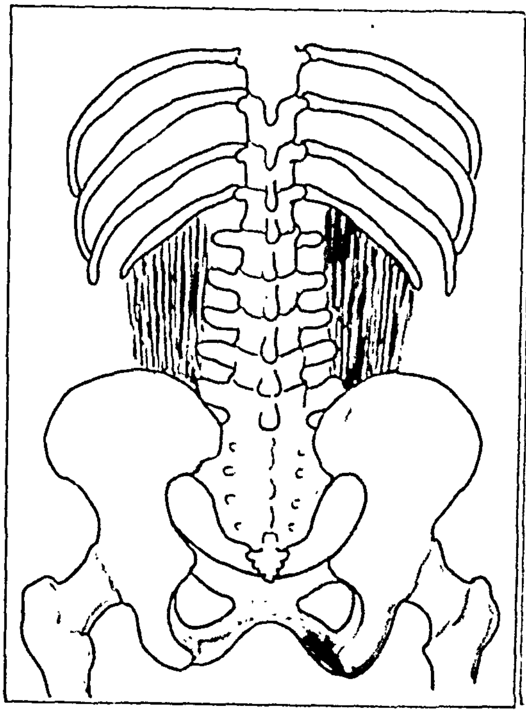

FIG. 1

Diagrammatic representation of the action of the quadratus lumborum muscles. When equal in strength, they help to maintain the pelvis in a horizontal position.

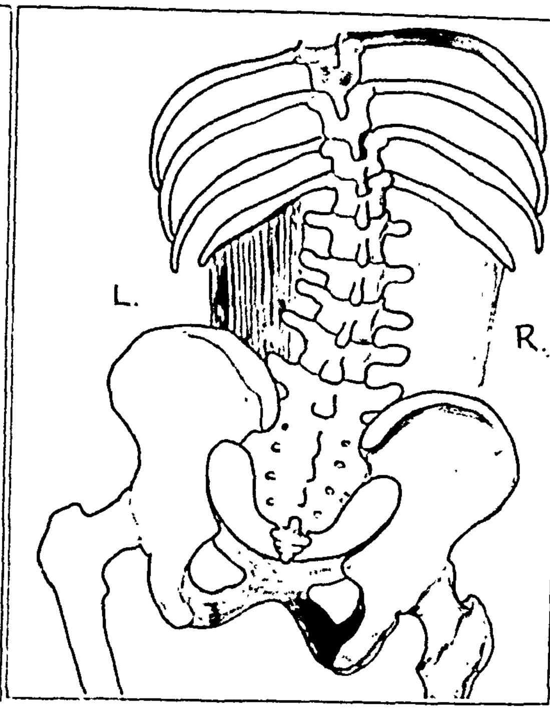

FIG. 2

Effect of paralysis of the right quadratus lumborum. Owing to the weakness of this muscle, the pelvi drops on the right side and the opposite quadratus contracts, thus holding the pelvis in an oblique position.

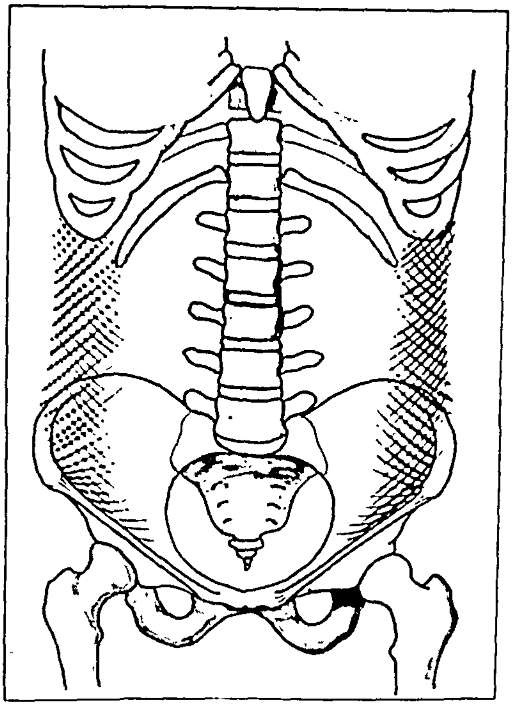

FIG. 3

Diagrammatic representation of the action of the external and internal oblique muscles. When equal on both sides, they, like the quadratus lumborum, help to hold the pelvis in a horizontal position.

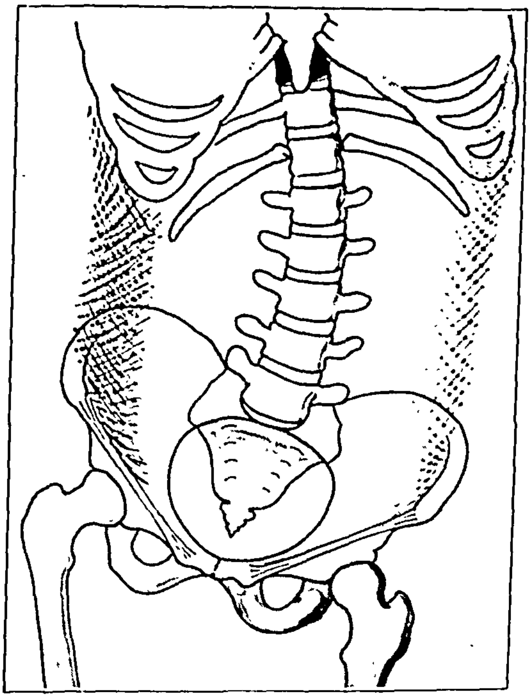

FIG. 4

Diagrammatic representation of the effect of paralysis or weakness of the external and internal oblique muscles of one side. The pelvis drops on the paralyzed side and the strong muscles contract, holding the pelvis in an oblique position.

Were it not for them, locomotion would be difficult, since they act with the abductors of the opposite hip to lift the pelvis of the swinging leg at each phase of the stride. If, however, as a result of infantile paralysis, the quadratus lumborum and the obliqui abdominis of one side become paralyzed, the opposing muscles of the opposite side will be permitted an undue range of contraction,—the pelvis will drop on the affected side and be lifted on the opposite side, resulting in the development of a scoliosis with its convexity toward the paralyzed side (Figs. 2 and 4). Beginning as a barely perceptible pelvic tilt, the deformity will, if unchecked, develop until one hip is three or four inches higher than the other; the spine becomes fixed in a scoliosis of such extreme degree that compensation is impossible and the body tilts far over toward the short leg. Locomotion becomes almost impossible. Frequently, secondary deformities of the hip and knee develop, the most common being an upward subluxation or dislocation of the hip on the short side and a hyperextension of the knee on the long side.

FIG. 5

Test for the action of the quadratus lumborum. As the patient pulls up—first on one side, then on the other—the examiner resists the motion by pulling downward on the ankles and thus is able to test the relative strength of the two muscles. This is not a pure quadratus action since the obliqui abdominis and the sacrospinalis also participate. *By palpating the quadratus, additional information can* be secured.

Warned by the pathetic picture presented by patients in these late stages, we have tried to diagnose this condition at its inception. This can be done only by demonstrating loss of power in the quadratus and the obliqui abdominis. The test for the quadratus which we have found most reliable is illustrated in Figure 5. With the patient

FIG. 6

The blowing test for the abdominal muscles. If there is a localized weakness of the abdominal muscles, a bulging will be noted, as indicated on the left side of the abdomen. This patient had only slight pelvic obliquity, owing to the presence of a strong quadratus on the left side.

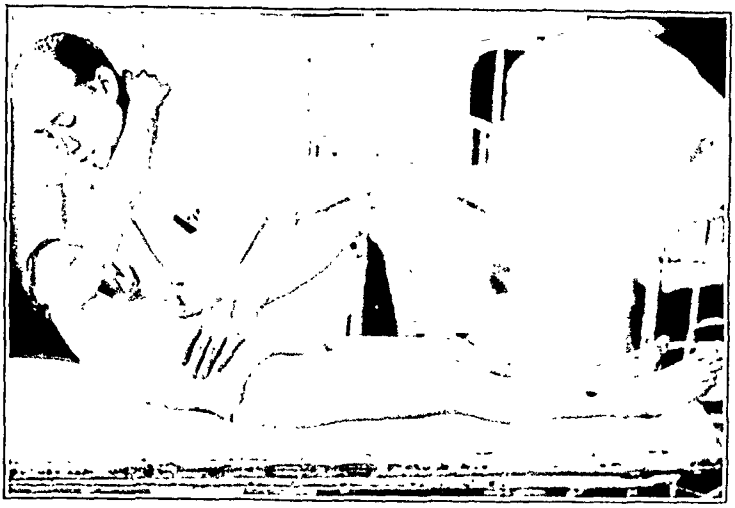

FIG. 7

Testing the strength of the lateral abdominal muscles. The patient, lying supine, grasps the examiner about the neck, thus lifting the body clear of the examining table. The body is brought far to one side and the patient is then asked to swing the body back to the neutral position. As this action is performed, the abdominal muscles are palpated by the physician. When the test has been done for the muscles of one side, the examiner moves to the opposite side of the table in order to test the opposite group of muscles.

in the supine position, the physician grasps both ankles and instructs the patient to pull up first one side of the pelvis, then the other. Of course other muscles besides the quadratus are concerned in this movement, but, by palpating the quadratus muscles during the manoeuver, much can be learned about their relative strength.

Lowman's tests for the lateral abdominal muscles are of great value and, in addition, the following methods may be employed. The patient is asked to blow out his abdomen as much as possible. If the lateral abdominal muscles are weak, they will balloon out, as shown in Figure 6. Next, the patient, lying supine, clasps the examiner with both hands (Fig. 7), thus lifting himself clear of the examining table. The physician flexes the patient's body toward the side, and then requests the patient to try to swing the body back to the neutral position. As this is done, the physician palpates the lateral abdominal muscles. The examiner then shifts to the opposite side of the table and repeats the test for the opposing muscles.

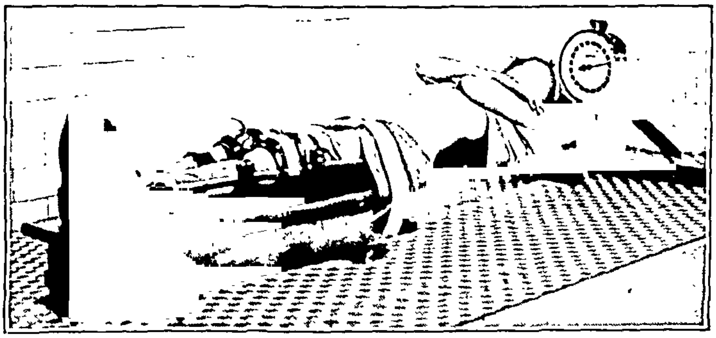

FIG. 8

Apparatus for registering in pounds the strength of the lateral abdominal muscles. The upper half of the wooden frame on which the patient is strapped moves freely on a pivot located beneath the sacrum. Lateral motions of this freely moving platform are transmitted by ropes running over pulleys to a spring balance which registers in pounds the force of the motion. This may also be measured by attaching a spring balance to a hook placed in the side of the wooden platform.

Since these tests, like most muscle examinations, have only relative accuracy, we have tried to measure the pull of the lateral flexors of the trunk by means of a spring-balance apparatus (Fig. 8). This consists of a wooden plat-

form mounted on a pivot so that it can swing easily from one side to the other. The patient's trunk is strapped securely to this platform, the legs being supported on a fixed board. As the patient contracts the lateral abdominal muscles—first of one side, then of the other—he swings the movable platform to and fro, the force of this motion being registered in pounds on a spring balance connected to the platform by cords running over pulleys. Another method, similar to the Lovett spring-balance tests, is to attach the spring balance to a hook on the side of the platform and to take a reading at the maximum degree of tension exerted by the patient.

Despite these studies, we are more than ever impressed with the inadequacy of the methods of testing the strength of the trunk muscles. One purpose of this paper is to stimulate further work on this important phase of pathological kinesiology.

Inaccurate though these methods have been, they have enabled us to detect weakness of the quadratus and the obliqui abdominis in a number of early cases of poliomyelitis. If this weakness is unilateral, a pelvic tilt has always been present. Figure 9 illustrates such a case. The left-hand photograph shows the patient eight weeks after the onset of the poliomyelitis. The left obliqui abdominis and the left quadratus were markedly weaker than the right; consequently, the right side of the pelvis has been pulled upward and a pelvic obliquity is present. This patient was treated conservatively for almost two years by the "push-and-pull" method. The right leg was pulled down and the left leg was shoved up (Fig. 10); yet, each time the traction was removed, the deformity returned within a few hours. The right-hand photograph, showing the patient two years later, illustrates the ineffectiveness of such non-operative treatment in the presence of a persistent inequality in the strength of the opposing trunk muscles.

FIG. 9

Photographs of a child with pelvic obliquity, due to weakness of the left obliqui abdominis and left quadratus. The left-hand figure illustrates the condition two months after the onset of infantile paralysis. The right-hand figure indicates the condition after two years of thorough non-operative treatment. Despite this, the muscle imbalance caused an immediate return of the obliquity as soon as the corrective apparatus was removed.

Having been taught by several such cases, we decided in the case of the next patient who came under our treatment not to wait until the conventional two-year period had elapsed, but, *as soon as we were convinced of a serious imbalance in the action of the trunk muscles*, to correct this by operation. In devising an effective procedure, we were greatly helped by the pioneer work of C. L. Lowman[1] who demonstrated the value of fascial transplants in the correction of weak abdominal muscles. For the purpose we had in mind,—namely, the lifting of one side of the pelvis—it seemed to us inadvisable to follow Dr. Lowman's technique, but, rather, to run the fascial transplant from bone to bone,—from the ninth rib to the iliac crest. We felt that in this way the dropping of the weak side of the pelvis could probably best be prevented.

FIG. 10

The "push-and-pull" apparatus used in non-operative correction of pelvic obliquity. The short right leg is being pulled downward by a ten-pound weight; the long left leg, encased in plaster-of-Paris to support the knee, is being shoved upward by a powerful spring encased in a wooden box.

The operation consists of the following steps:

1. A transverse incision, four inches long, is made following the course of the ninth rib from the anterior axillary line to the sternum. The rib is exposed for a distance of two inches and is denuded of periosteum. A silk guide suture is then passed about the rib and the loop of the suture is left projecting from the lower surface. This is done so as to permit the fascial graft to be carried completely around the rib. The fascia in the region of the sternum is slit for a distance of two inches to allow the attachment of the inner tail of the fascial graft (Step 4).

2. A four-inch incision is made along the course of the ilium from a point three inches back of the anterior-superior spine to a little below the origin of Poupart's ligament. The crest of the ilium is split off for a distance of three inches, thus forming an osteoperiosteal flap to which the fascia lata is still attached.

3. A broad tunnel is now made, connecting the first incision with the second. This tunnel runs through the subcutaneous tissues just superficial to the abdominal fascia. It must be at least three inches wide throughout its extent. It is best made with a strong clamp and then widened by the fingers of the operator. If there are any bleeding points, they must all be caught and clamped. This can be done by lifting up the skin of the abdomen with long retractors. Two guide sutures are passed

through this tunnel,—one on the mesial side and the other on the lateral side.

4. Through a lateral incision, extending the entire length of the thigh, a strip of fascia lata is removed. This must be sufficiently long to reach from the iliac crest up to and around the ninth rib. It must be at least three inches wide and at one end should be slit so as to form two tails,—one for the rib attachment and the other for the sternal attachment.

5. The strip of fascia lata is drawn through the abdominal tunnel by means of traction sutures which have been caught in the two guide sutures during the third step of the operation. Great care must be taken that this strip does not twist, but remains flat. The fascia is fastened first to the crest of the ilium and Poupart's ligament by a series of No. 1 chromicized gut sutures. A second series of sutures is taken, bringing the osteoperiosteal flap back into its original situation. Thus, the fascia is fastened to the bone by means of a double series of sutures. Fixation must be secure enough so that eight or ten pounds of force may be applied to the fascia without disturbing its attachment. The upper end of the fascial transplant, which has been split longitudinally into two halves for a distance of three or four inches, is then sutured. The lateral half is drawn about the rib by means of the guide suture previously placed during the first step of the operation. While an assistant pushes up strongly on the pelvis and another assistant exerts lateral pressure on the body of the patient so as to approximate the ribs and the pelvis to the maximum on the affected side, the fascia which has been drawn about the rib is fastened to itself by three or four chromicized gut sutures. The mesial tail of the fascia is then fastened under strong tension to the fascia close to the sternum. When this step of the operation has been completed, the fascia should be felt as a tight band extending from the crest of the ilium up to the ninth rib. A half dozen additional sutures are taken to the margins of the fascial transplant, uniting these to the abdominal muscles in such a way as to keep the fascia as broad as possible and in the most intimate contact with the abdominal muscles. All incisions are then closed.

FIG. 11

H. A., a patient with paralytic obliquity, due to weakness of right obliqui abdominis muscles and right quadratus. Despite non-operative treatment for a period of six months, the right side of the pelvis dropped as soon as the corrective apparatus was removed. A fascial transplant was done February 21, 1934. Photograph shows the result approximately one year after operation. The pelvic obliquity has not recurred, and the patient walks with only a slight limp.

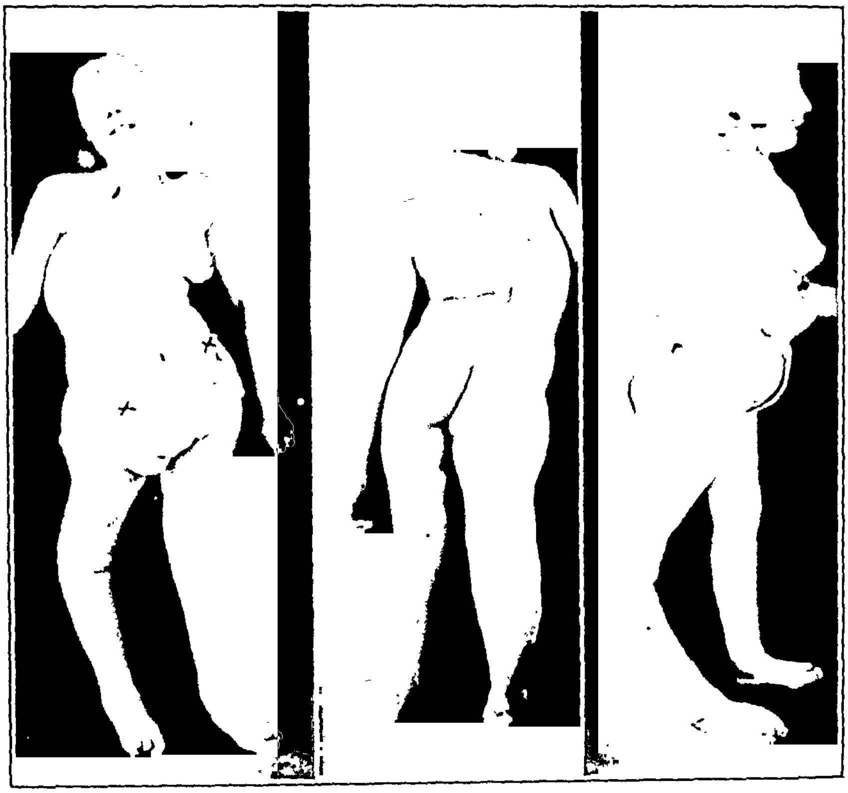

Fig. 12-A Fig. 12-B Fig. 12-C

R. R., before treatment, showing fixed paralytic pelvic obliquity, right lumbodorsal scoliosis, and recurvatum of the right knee.

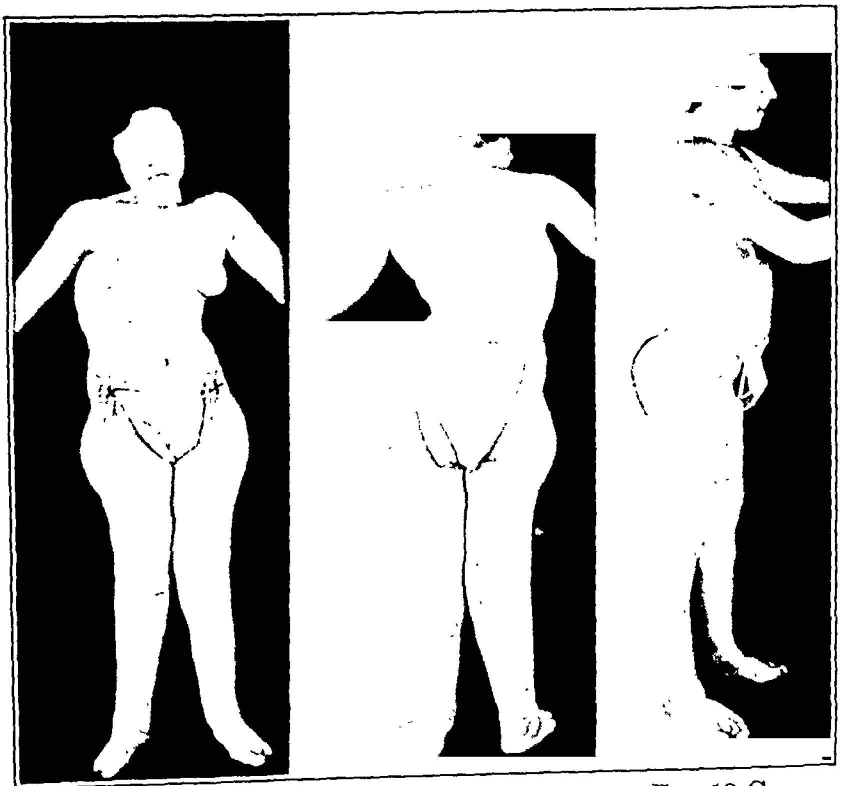

Fig. 13-A Fig. 13-B Fig. 13-C

R. R., after six months of treatment. The following operations had been done:

1. Division of spinal ligaments ("spinal release");
2. Fascial plastic for the paralyzed right abdominal muscles;
3. Bone-block operation for recurvatum of right knee. Note the correction of the pelvic obliquity and the recurvatum and the improvement in the scoliosis.

Fig. 14
Roentgenogram of patient R. R. at time of her admission, showing the pelvic obliquity and the subluxation of the left hip.

Fig. 15
Roentgenogram of pelvis of patient R. R. after six months of treatment.

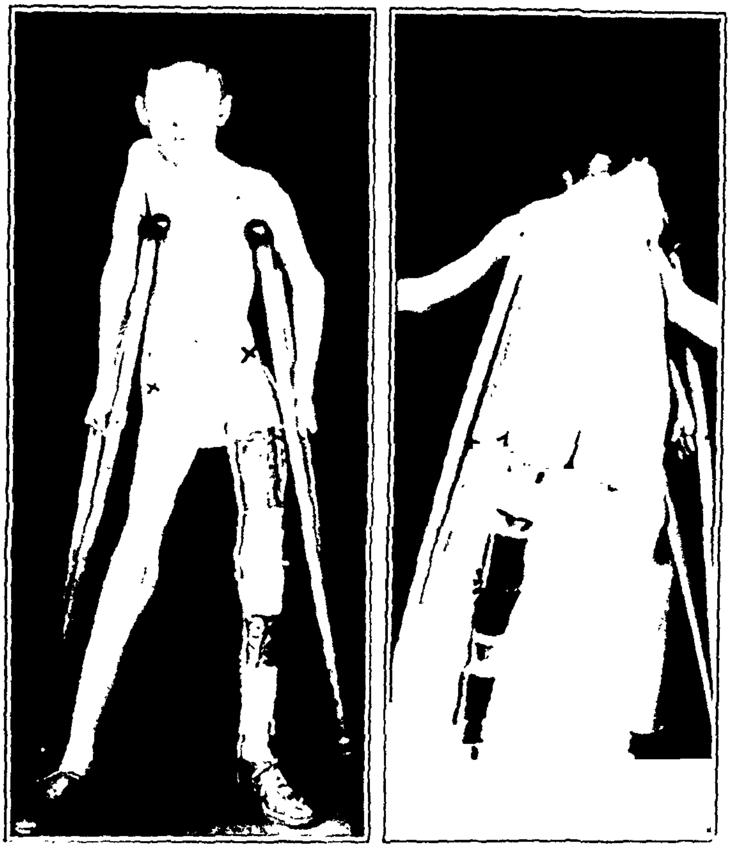

Fig. 16

J. R. at the outset of treatment. Note the pelvic obliquity, the severe right lumbodorsal curve, and the obvious difficulty in maintaining balance.

The effect of the operation in the following early case of pelvic obliquity has been most gratifying.

H. A., a male, aged twenty-two, was admitted to the Hospital for Joint Diseases suffering from poliomyelitis in a subacute stage. The onset had occurred seven weeks before admission. The *striking feature of the case* was the marked weakness of the right quadratus and the right obliqui abdominis. This showed itself by a downward tilt of the right side of the pelvis.

By applying traction to the left leg and an upward push to the right leg, which had been encased in plaster-of-Paris, it was possible to keep the pelvis horizontal. However, after six months in bed, the marked imbalance in the action of the trunk muscles was still present. When the patient was allowed to get out of bed, the pelvic tilt became evident not only when

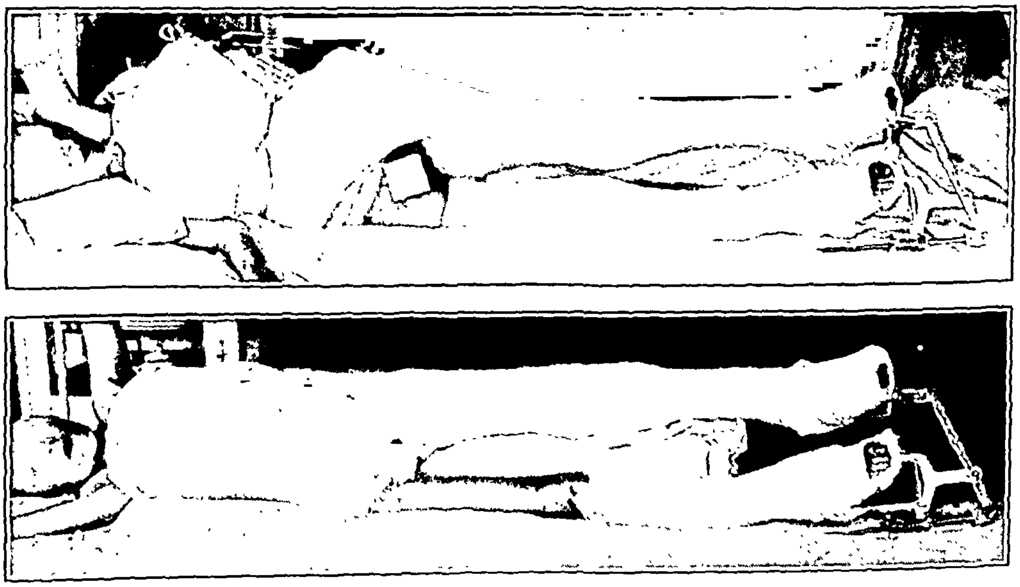

Fig. 17

J. R., showing correction of pelvic obliquity by means of the Roger Anderson traction splint. This had the double effect of pulling down on the short left leg and pushing up on the long right leg. The upper photograph shows the additional correction of the scoliosis *by means of the turn-buckle jacket.*

standing still, but even more when the patient tried to walk. It was then noted that, despite the good left gluteal muscles, he could not advance the right leg because the pelvis dropped on the right side. The fascial plastic operation was then performed in which the fascial grafts ran from the right ninth rib to the right iliac crest. The result nine months after the operation is shown in Figure 11. There has been no return of the pelvic tilt and the patient walks remarkably well considering the degree of his paralysis.

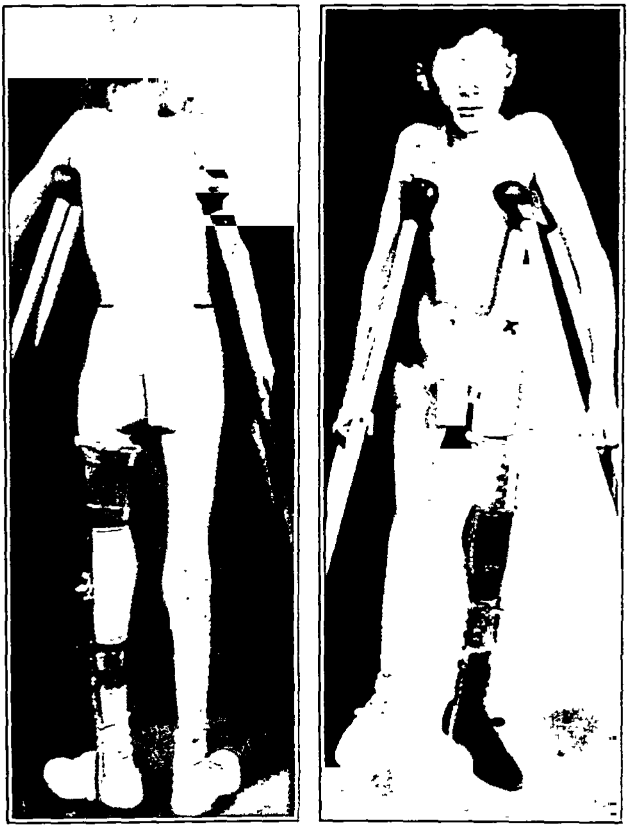

FIG. 18

J. R., after four months of treatment. The following operations had been done:
1. Division of spinal ligaments ("spinal release");
2. Fascial graft for paralyzed right abdominal muscles.

No deformity of the rib has developed in this case or in the fifteen other cases in which the same technique was employed.

The late cases of pelvic obliquity, due to imbalance of the trunk muscles, present at first sight an almost impossible therapeutic problem. The pelvis tilts at an angle of 20 to 50 degrees, making one leg two to four and one-half inches longer than the other. The spine is fixed in a curvature so extensive as to baffle correction by any method heretofore devised. The majority of patients who came to us had been under treatment in clinics of recognized standing and yet these terrifying deformities had been allowed to develop under the eyes of the attending surgeons who apparently had satisfied their therapeutic urge by performing astragalectomies or similar equally ineffective operations in no way connected with the all-important pelvic problem. Most of these patients were unable to walk; they could just balance in the standing position by hyperextending the long leg (Figs. 12-A, 12-B, and 12-C) or by holding it in marked abduction. Two patients wore spinal braces which were obviously ineffective. Of course, no brace could possibly give support to such a markedly decompensated scoliosis as that depicted in Figures 12-A, 12-B, 12-C, and 16.

The picture was all the more pathetic when illuminated by the fact that all this deformity could have been prevented by adequate treatment

in the early stage. Orthopaedic surgeons must realize that a fixed pelvic obliquity is one of the most crippling of the paralytic deformities and that, like equinus, knee contracture, or drop wrist, it can be prevented from developing.

But what is one to do in the cases in which this deformity is already present? Our method has been the following:

First, traction is applied to the short leg. This can best be done either by the Roger Anderson splint (Fig. 17) or, in the worst cases, by skeletal traction.

Traction alone, however, is not sufficient; the contracture between spine and pelvis should be released and the scoliosis, if not cured, at least should be reduced to a reasonable degree of compensation, permitting resumption of the upright position. In two cases, traction to the trunk, followed by application of lateral-flexion turn-buckle plaster corsets by the Hibbs method, gave fair correction. In the other cases, an operation which the author terms "spinal release" was done. By means of this procedure, the lumbar spine, sacrum, and high side of the pelvis are exposed. Every accessible spinal ligament is cut,—the ligamenta interspinalia, the ligamenta subflava, and the capsules of the intervertebral articulations. Particular care is taken to free the lumbosacral liga-

FIG. 19

Roentgenogram of patient J. R., indicating the pelvic obliquity and the right lumbodorsal scoliosis. For clarity in reproduction, the iliac crests have been retouched.

FIG. 20

Roentgenogram of patient J. R. after six months of treatment.

ments on the low pelvic side as well as on the high pelvic side. Unless this is done, it is impossible to swing the spine out of its deformed position. One must be extremely thorough and at the same time not perforate the dura. This trauma can occur so easily that the author has devised a special instrument—a chisel with a shoulder one-fourth of an inch from the cutting edge—which will not slip and cut the dura as the ligamenta subflava are cut. Although we have also divided the fascia and muscles of the concave side of the curve, this has apparently not aided materially in the correction. Thus far, to avoid shock a complete stripping of the quadratus lumborum from the iliac crest has not been attempted, but this step seems to be an obvious extension of the principle of the operation and we intend to adopt it in treating our next case. The "spinal-release" operation has been performed five times. In each case it has resulted in a marked improvement, best demonstrated by the roentgenograms (Figs. 14, 15, 19, and 20). We have not considered it wise to seek correction by the application of plaster-of-Paris at the time of the operation: in each case, we have waited one week until the trauma of the operation has subsided. Then, with the patient under avertin anaesthesia, a plaster spica has been applied, with maximum correction of the pelvic obliquity and of the scoliosis.

The third step of the reconstruction process is the maintenance of correction. This is unquestionably the most difficult part of the reconstruction program and we are still uncertain which procedure is most likely to be effective. Our first experience in a severe case, though disappointing, was sufficiently instructive to warrant reporting.

In this patient, I. K., the obliquity was caused by a paralysis of the right obliqui abdominis and the quadratus lumborum. After satisfactory correction of the deformity had been obtained by a series of turn-buckle plaster jackets (Hibbs method), a fusion of the spine was performed from the ninth dorsal vertebra to the fourth lumbar vertebra. The back was immobilized for three months after the operation and then a firm leather corset was applied. A year later the result was still satisfactory (see Figure 18 in previous paper [2]), but when the patient was next seen, after a lapse of three years, a severe recurrence of the obliquity had occurred. Careful analysis of the roentgenograms of the spine showed that this recurrence was due to a marked increase of the curvature above and below the fused area. The fused portion of the spine had changed only slightly since the operation.

The question naturally arises: Could the recurrence have been prevented by fusing a longer area of the spine, including the lumbosacral joints? The author was averse to a fusion of the spine to the sacrum, since, in the particular case under discussion, the patient's mode of walking seemed to demand the maximum degree of freedom of the spine and pelvis. Therefore, an attempt was made to correct the imbalance of the trunk muscles by performing the abdominal fascial plastic operation after the pelvic obliquity had been overcome a second time by our usual methods.

This operation was done a year ago. Thus far there has been no return of the obliquity, but the observation period is too short to be certain of the permanence of the result.

In four other cases, maintenance of correction by the abdominal-fascial plastic operation has been attempted. Since it is obvious that this cannot give complete replacement of the paralyzed trunk muscles, it has been supplemented by the use of a carefully fitted spinal brace of a modified Hessing type and by a rigorous system of exercises. In all four cases, some of which have been under observation over two years, there has been no recurrence. It may be possible to free these patients from the necessity of wearing the back brace by fusing the spine. The difficult problem, however, is to determine accurately the extent of the area of fusion, and, above all, whether the patient's gait will be helped or impaired by fusing the lumbosacral joints. Only further experience can answer this question.

SUMMARY

Fixation of the pelvis in an oblique position constitutes a major postparalytic deformity. There are two main etiological types of pelvic obliquity: first, that due to imbalance of the abductors and adductors of the hips: second, that due to imbalance of the trunk muscles. Both types may be recognized by muscle tests at an early stage, and frequently appropriate postural treatment will cure the condition. However, if muscle imbalance persists, operation is indicated. This is best done at an early stage before the deformity has become marked. Of the late cases of deformity, those of the first type may be completely and easily cured by the division of the contracted abductor and adductor muscles, as a rule combined with the use of a fascial transplant. The second type, however, demands a complex series of corrective procedures consisting of: (1) preoperative traction by the direct skeletal method or Roger Anderson splint; (2) operative release of the contracted spinal ligaments and muscles; and (3) maintenance of the correction by fascial transplant to replace the paralyzed obliqui abdominis and quadratus lumborum, supplemented by a suitable back brace or spinal fusion. The rules for determining accurately the extent of the area to be fused have not yet been formulated.

1. Lowman, C. L.: The Relation of the Abdominal Muscles to Paralytic Scoliosis. J. Bone and Joint Surg., XIV, 763, Oct. 1932.
2. Mayer, Leo: Fixed Paralytic Obliquity of the Pelvis. J. Bone and Joint Surg., XIII, 1, Jan. 1931.

THE RELATION OF THE PROSTATE GLAND TO ORTHOPAEDIC PROBLEMS *

BY WALLACE S. DUNCAN, M.D., CLEVELAND, OHIO

There is a surprisingly high incidence of prostatic infection in patients whose histories give no indication of infection in the genito-urinary tract. Chronic infection in the prostate and seminal vesicles is extremely common and may exist for years without producing symptoms. These organs are not always investigated, even when the patient is affected with chronic joint disease or some other remote ailment. Too infrequently is the prostate looked upon as a possible focus of infection in patients whose symptoms are indicative of the presence of general toxaemia.

A relationship between the prostate and some orthopaedic problem is found most commonly in the following conditions: (1) involvement of one or more joints, with the prostate as a focus of infection; (2) prostatitis, associated with pain in the lower back; (3) malignancy of the prostate gland, with or without metastases.

Every man with a pain in the lower back, or with arthritis in one or more joints, should be examined both by a genito-urinary surgeon and by an orthopaedic surgeon. It is almost impossible for any one other than an urologist to determine satisfactorily the condition of the prostate. Certainly, if digital examination alone in the hands of genito-urinary specialists furnishes inconclusive evidence in regard to the presence or absence of infection in the prostate gland, many cases of such infection must be overlooked when the same examination is made by those who are not specialists in this field. If the diagnosis is questionable, it may be necessary to examine the prostatic secretion repeatedly.

The Prostate as a Focus of Infection in Chronic Arthritis

The group of cases in which involvement of one or more joints is associated with a focus of infection in the prostate is of the greatest importance from an economic point of view. Of 1,252 male patients with joint symptoms, seen within the past five years at the Cleveland Clinic, all had joint symptoms sufficiently severe to cause them to seek medical advice. Of this total number, 752, or 60 per cent., were examined in the Genito-Urinary Department. Of these 752 patients, 312, or 41 per cent., had a definite prostatitis. This number represents approximately 25 per cent. of the whole group, but, if all the patients had been subjected to genito-urinary study, it is likely that the incidence of prostatic infection might have been as high as in the smaller group of patients who were referred for urological examination.

Of the patients in whom prostatitis was present, 53 per cent. were

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, New York, N. Y., January 16, 1935.

between the ages of thirty and fifty, and 88 per cent. between the ages of twenty and sixty years. A definite history of gonorrhoea was obtained in approximately 40 per cent. of these cases. The presence of syphilis was not a common finding; the blood Wassermann test showed positive reactions in twenty-six of 670 patients examined,—an incidence of 3.8 per cent.

Examinations of the teeth and throat were made in 280 of the 312 patients with prostatitis. Of this number, forty-nine, or 17 per cent., had dental infection; sixty-six, or 23 per cent., had infected tonsils; and fifty-two, or 18 per cent., had both dental and tonsillar infections. These findings are not necessarily an indication that the prostate is a more frequent focus than the tonsils or teeth, since many of these patients had been examined previously for the most obvious sources of infection. It does show, however, that the prostate is as important as any other possible source of infection, and is often a more dangerous factor in the patient's disability because less thought and consideration are given to it.

The following cases illustrate the necessity for careful study of the prostate in arthritis.

Case 1. An unmarried man, twenty-eight years of age, had had soreness of the feet for three or four years. The right ankle had been affected first and, when no relief had been secured by local measures, the patient's tonsils were removed. His feet had then been symptom-free until eight months prior to admission, when pain, which was constantly present on walking, developed under both heels and in the anterior part of each foot. A tooth was extracted without effecting any relief.

There was considerable inflammatory reaction about both feet, with tenderness through the metatarsophalangeal joints and along the lateral borders of each os calcis. The nose, throat, and teeth displayed no evidence of infection. The patient denied having had gonorrhoea. On first examination, the prostatic secretion showed eight to ten pus cells per high-power field. In two days, the prostatic secretion was reexamined and showed from fifteen to twenty pus cells, with occasional clumps. With prostatic massage and general measures, the patient's joints became entirely symptom-free.

Case 2. A man, aged sixty-four years, had bumped his right knee against the running board of a car seven months before admission. The knee became swollen and contained fluid. An orthopaedic surgeon had tapped it on twenty-five occasions, and twice had injected iodoform emulsion. The fluid from the knee was always sterile. About six weeks prior to admission, the patient had begun to have pain in the left knee which became swollen and contained some fluid.

The clinical examination revealed definite rigidity in the lumbar spine. The knees were swollen and hot and were in a position of flexion, with marked restriction of movement. Clinically, the condition simulated an infectious polyarthritis.

The patient's general physical condition was good. The tonsils had been removed; there was no gross evidence of infection in the teeth. The patient had had some nocturia, but there was no pain on urination and no urethral discharge. He had never had a gonorrhoeal infection. From the time of his admission, examination of the urine showed the presence of pus cells, varying from five to forty in each high-power field. Examination of the prostatic secretion showed fifty to seventy pus cells per high-power field, with considerable clumping. This condition was looked upon as a non-specific prostatitis and seminal vesiculitis.

Eventually the patient was sent to Arizona, where he was placed under a definite regimen—including heliotherapy, care of the prostate, and correction of the deformities. He made an excellent recovery and is now able to carry on normal activities, including the playing of golf.

Considering the absence of other sources of infection and the response to prostatic care, infection in the genito-urinary tract must obviously be regarded as the basis of the difficulty. This case is significant because the patient's symptoms had been present for seven months before any investigation of the urinary tract was made. It also brings out the significance of trauma and the apparent localization of what would appear to be a blood-borne infection.

Prostatitis Associated with Pain in the Lower Back

Of 238 cases in which the chief complaint was of low-back pain, foci of infection were discovered in the teeth in twenty-eight cases, in the tonsils in forty-five cases, and in both the teeth and the tonsils in thirty-four cases. The prostate was examined in only 153 cases: infection was found in eighty-three cases and no infection in seventy cases. In eighty-five cases, or 35.7 per cent. of the series, the prostate was not examined.

After reviewing many cases of backache, it is evident that certain symptoms are of considerable significance in arriving at the conclusion that the prostate may be a factor in the causation of the pain. In many cases, the onset of the discomfort is insidious. A typical history is that the patient is frequently awakened early in the morning by discomfort in the lower back, which can be relieved by changing the position in bed and also by voiding. On arising, he may or may not have moderate stiffness on bending over. As in many mechanical defects, the discomfort becomes worse when the patient is on his feet for any length of time. He frequently complains that the pain is "deep" in his lower back.

Such a man, over a period of months or even years, may have been treated by removal of tonsils and abscessed teeth, by the use of a low-back support, and by innumerable types of physiotherapy and manipulation. Later, the discovery and proper treatment of a prostatic infection have resulted in complete relief from the backache and the general symptoms, within a relatively short period of time.

The following case illustrates the importance of this point:

CASE 3. A married man, aged thirty-six years, for twenty-eight months before admission had suffered acute pain in the region of the right sacro-iliac joint while lifting. Treatment had consisted of long periods of rest in bed, manipulation of the back, and tonsillectomy, but no relief whatever had been obtained. Fusion of the sacro-iliac joint was contemplated.

Clinical examination revealed no classical signs of a right-sided sacro-iliac inflammation. No focus of infection was evident in the nose or throat, but there were twelve abscessed teeth. The prostate was boggy, and its secretion was loaded with pus cells, many of which formed clumps.

After the institution of treatment of the prostate and fitting the patient with a sacro-iliac support, much relief was obtained, although the teeth had not yet been extracted.

The necessity for repeated microscopic examination of prostatic secretion, if the diagnosis is questionable, is demonstrated by the following experience:

CASE 4. A man, aged twenty-three years, came to the Clinic with the complaint of aching in the lower back. A mechanical defect was thought to be the causative agent. Prostatic examination was made, and showed nothing of significance. However, within a week, the patient went to a dispensary, where it was found that the prostatic secretion was loaded heavily with pus. Following adequate treatment of the prostate, the pain in the back was completely relieved.

Malignancy of the Prostate with or without Metastases

Carcinoma of the prostate gland is a genito-urinary problem of interest to the orthopaedic surgeon in the differential diagnosis of pain in the lower back. In a series of 308 cases of carcinoma of the prostate seen at the Cleveland Clinic, proved bone metastases were present in eighty-five cases, and in each of these patients there was a marked preponderance of these secondary growths in the pelvis and bones of the spine.

In such cases, the pain is usually most severe at night and is relieved when the patient gets up and walks about. This is directly at variance with the symptoms related by the average patient whose back disability is attributable to some other cause. The freedom of movement in the lower back is usually found to be out of all proportion to that in patients whose symptoms are due to arthritis in the lumbar spine.

The symptoms caused by metastases to the bones from a malignant growth in the prostate are usually of long duration, as contrasted, for instance, with those from secondary growth from the breast. This is because the process in the bone is of a sclerosing type, rather than an osteoclastic type. Despite the long duration, if pain is a prominent symptom, roentgenotherapy is indicated as a palliative measure.

CONCLUSIONS

In no field of medicine or surgery has the significance of prostatic infection been brought out more strikingly than in orthopaedic surgery, and, even yet, the importance of this type of disease is insufficiently emphasized. In the presence of other sources of infection, it is impossible to be too dogmatic about the exact rôle played by prostatitis in the production of joint disturbances. However, one has only to follow from a clinical point of view the degree of improvement which some of these patients make in every respect, when adequate investigation and care of the prostate are instituted, to realize the importance and efficacy of this method of approach.

Certainly, sufficient evidence exists to show that prostatic infection, even though latent, is in many instances an important etiological agent in the production of pain in the lower back and in many cases of joint disease. Clinical experience has proved that, despite the necessity for prostatic supervision and the tendency toward recurrence of infection in the gland, symptomatic treatment of prostatitis, either alone or in conjunction with the care of other focal infections and general hygienic measures which improve the patient's general physical state, is, in the great majority of instances, accompanied by definite alleviation of the symptoms of joint disease.

THE RÔLE OF THE ILIOTIBIAL BAND AND FASCIA LATA AS A FACTOR IN THE CAUSATION OF LOW-BACK DISABILITIES AND SCIATICA*

BY FRANK R. OBER, M.D., BOSTON, MASSACHUSETTS

Pain along the course of the sciatic nerve can be one of the most disabling and distressing symptoms that man can suffer. There have been innumerable articles published on this subject describing causes and giving suggestions for relief of this condition. It is the purpose of this paper to discuss sciatic pain and its relation to certain mechanical conditions of the iliotibial band and the fascia lata, and the relation of these structures to their muscular attachments with regard to disabilities of the sacro-iliac and lumbosacral joints.

It has been shown that relief of sciatic pain often comes very quickly following sacro-iliac arthrodesis after the method of Smith-Petersen. Such early relief is not to be explained as a result of the fusion, because solid fusion does not occur so rapidly. Roberts, twelve or fourteen years ago, operated on a patient with sciatic pain to relieve what seemed to be a pathological condition of the ilium as shown by x-ray. The Smith-Petersen incision was used. No bone pathology was found and the wound was closed. The patient was relieved. Following this case, Roberts performed the same operation in sixteen other cases and obtained complete relief in all but one. Roberts did not publish his work. Heyman performed a similar operation and obtained a like result.

It would seem logical that the relief of symptoms in these cases might be due to releasing the fascial pull exerted through the fascia lata and its attachments to the gluteus maximus muscle.

ANATOMY

The iliotibial band extends from the crest of the ilium to the lateral tuberosity of the tibia, the head of the fibula, the external condyle of the femur, and the intermuscular septum between the hamstrings and the vastus lateralis. Above, the fascia lata is attached to the coccyx, sacrum, and crest of the ilium and, in part, to Poupart's ligament and the os pubis; internally, to the ramus and tuberosity of the ischium and the lower part of the great sacrosciatic ligament. Laterally, the greater part of the tendon of the gluteus maximus muscle is inserted into the fascia lata and, anterolaterally, the tensor fasciae latae is also inserted into the iliotibial band which is the tendon of the tensor. In many instances, the iliotibial band is thicker than normal above these muscular attachments and is contracted.

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 6, 1935.

PATHOLOGY

The origin of the muscular attachments of the gluteus maximus and the tensor fasciae latae represents the base of a triangle whose apex is over the lateral aspect of the femur just below the trochanter. When there is a shortening of the iliotibial band and its fascial expansion, there is an abduction contracture of the femur, resulting in a tremendous leverage action on the sacro-iliac and lumbosacral joints. In most instances, the anterior portion of the fascia lata is contracted; in some, the posterior portion is contracted.

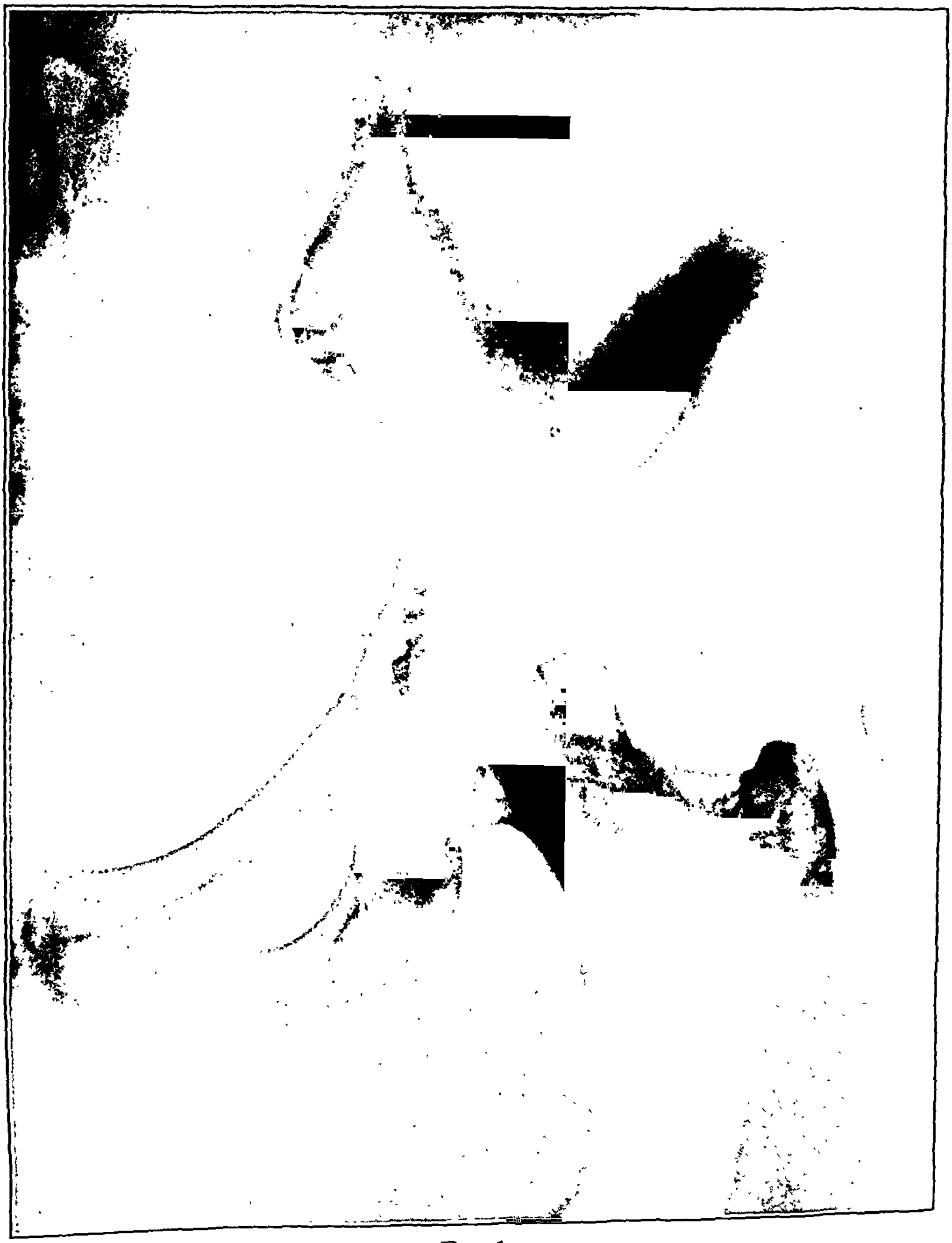

Fig. 1

F. W. Roentgenogram of hip showing calcareous deposit in fascia lata. The removal of this deposit resulted in partial relief of lame back and sciatic pain.

The sciatic nerve lies beneath the gluteus maximus where it emerges below the piriformis and any contracture of the fascia lata must exert muscular pressure on this nerve. In operations on the iliotibial band, the gluteus maximus muscle has been found to show more or less spasm.

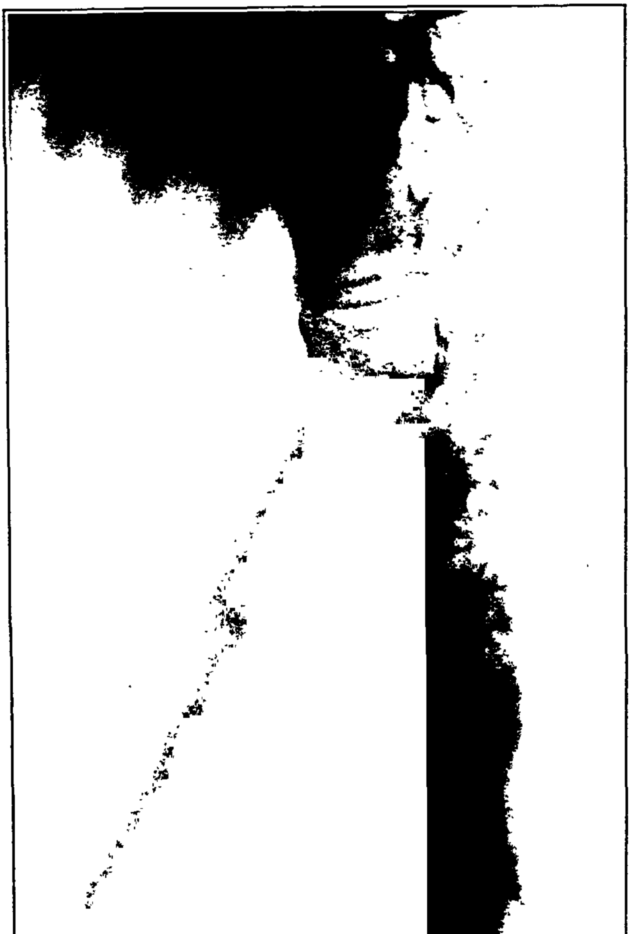

Fig. 2

Mrs. A. T., September 20, 1934. Before operation. Lateral view of lower spine in a case of lame back with double snapping hips.

SYMPTOMS

Patients with contracted fasciae latae and iliotibial bands complain of pain in the lumbosacral or sacro-iliac regions. They may have pain in the dorsal region if there is marked lumbar lordosis and, in some instances, the pain may occur at the cervicodorsal junction.

EXAMINATION

These patients with contracted iliotibial bands exhibit the signs and symptoms which are associated with other low-back difficulties. They have limitation of motion, muscle spasm, tenderness over the lumbosacral and sacro-iliac regions and posterior to and just below the greater trochanters, sciatic scoliosis, limitation of straight-leg raising, positive Ely's sign, and functional scoliosis if the abduction contracture is unilateral.

The method of eliciting the abduction sign is as follows: The patient lies on his side, with the thigh next to the table and flexed enough to *obliterate any lumbar lordosis*. The upper leg is flexed at a right angle at the knee. The examiner grasps the ankle lightly with one hand and steadies the patient's hip with the other. The upper leg is abducted

FIG. 3

F. S., November 13, 1934. Before operation. Lateral roentgenogram showing lumbar lordosis.

widely and extended so that the thigh is in line with the body. If there is any abduction contracture, the leg will remain more or less passively abducted, depending upon the shortening of the iliotibial band. This band can be easily felt with the examining fingers between the crest of the ilium and the anterior aspect of the trochanter.

OPERATION

Since the first article[2] on this subject was written, the line of skin incision has been changed. The incision is oblique and begins at a point a little lateral to the anterior iliac spine, extending downward and backward to a point about one inch posterior to and one inch above the greater trochanter and exposing the fascia lata. The iliotibial band and fascia lata are next incised posteriorly well over the anterior portion of the gluteus maximus muscle. The incision is now carried forward to a point just below the anterior-superior spine and includes the fascia surrounding the tensor fasciae latae. All intermuscular septa in this region are divided.

As soon as the section is completed, there is a marked separation of the cut surfaces. The fascia is further separated by blunt dissection until there is a gap of two inches. In some instances, pathological examination of the iliotibial band has shown chronic inflammation.

RESULTS

Since May 2, 1934, the author and his associates have operated upon forty-two patients. The left side was affected in fourteen cases and the right in twelve, making a total of twenty-six cases of unilateral involve-

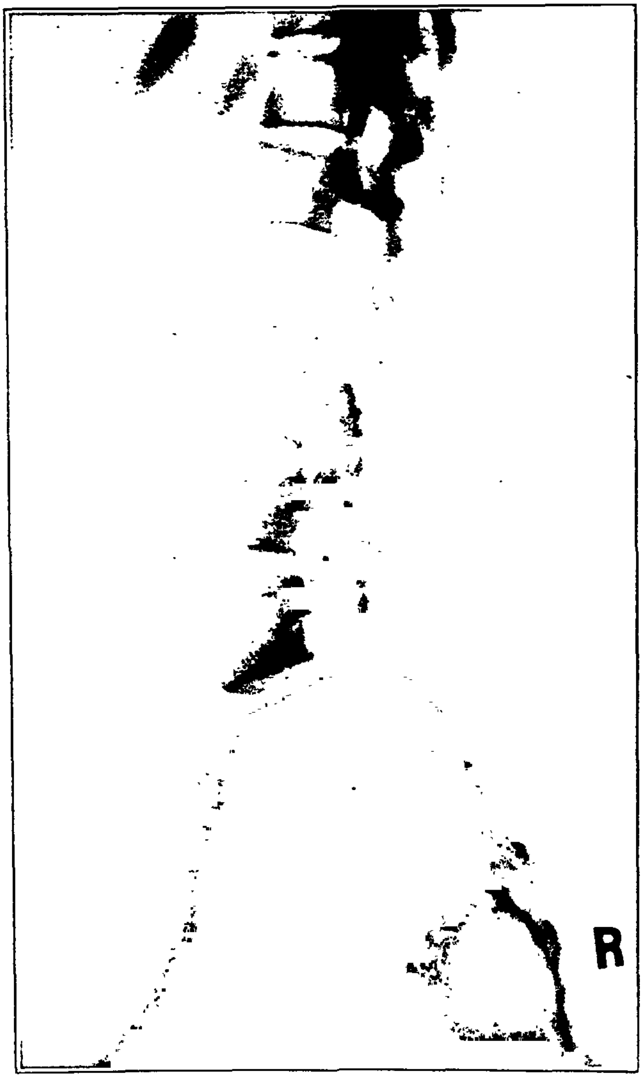

Fig. 4

F. S., March 12, 1935. Two months after operation. Lateral roentgenogram showing lessened lumbar lordosis.

ment. There was bilateral involvement in sixteen cases.

In a few instances, there has been relief at operation. In most cases, the relief from pain in the sciatic nerve begins on the fifth to the tenth day after operation. In other instances, where there has been a marked diminution of sciatic pain, slight twinges have persisted. There was one case of moderate recurrence ten weeks after operation, following a two-day motor ride of 1,000 miles.

Straight-leg raising increases steadily after operation. The lame back clears up in from six weeks to six or eight months, but occasionally lasts longer. The motions of the spine return to normal and the sciatic scoliosis disappears. Patients with lordotic or flat lumbosacral angles improve so that nearly a normal lumbar lordosis results. Posture improves, the increased compensatory curves decrease, and pain at the root of the neck disappears.

SUMMARY

1. The simple surgical procedure described relieves sciatic pain in spines which show no bone pathology by x-ray.

2. Contracted iliotibial bands and fasciae exert pulls on the pelvic bones, resulting in bad posture.

TABLE I

Results of Operation

Involvement	Patients Well	Patients Improved	Patients Not Improved	Total No. of Patients
With sciatica:				
Bilateral	2	4	1*	7
Unilateral	16	3	4	23
Without sciatica:				
Bilateral	3	3	3	9
Unilateral	2	0	1	3
Total	23	10	9	42

* Operation performed too recently to judge results.

3. One more diagnostic sign has been added to our present knowledge of low-back disabilities, which should be helpful in clearing up another group of lame backs that have not responded well to other treatment.

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SACRARTHROGENETIC TELALGIA

I. A Study of Referred Pain

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This article is the first of a series * of five, the preparation of which was begun in January 1929. It is based upon the analysis of 506 examinations for low-back disability, chosen from a series of nearly 1,000 because of their completeness. Its scope is limited to a study of the pain caused by lesions of the sacro-iliac and sacrolumbar joints, and its purpose is to advance the following definition in the interest of more accurate anatomical nomenclature.

"Sacrarthrogenetic telalgia" is in no sense a diagnosis, but is a descriptive term that should be applied to the typical syndrome of pain which originates in the sacro-iliac and sacrolumbar articulations and their accessory ligaments. The referred pain (telalgia) affects the gluteal or the sacral region, or both regions, and may affect any part or all parts of the lower extremities and genito-inguinal regions except the internal crural and plantar regions. The lesions that produce this type of pain are associated with lateral spinal scoliosis. They do not cause objective neuropathological manifestations other than reflex physiopathic disorders and the atrophy of disuse.

In reviewing the literature, we have encountered five outstanding sources of confusion, the first of which is inaccurate nomenclature. "Essential", "symptomatic", "primary", or "idiopathic sciatica", "sciatic neuralgia", "sciatic pain", and "sciatic scoliosis" are terms frequently used in connection with dysfunction of the sacro-iliac and sacrolumbar joints [10, 18, 56]. By definition, sciatica is the "term commonly applied to all affections of which the chief symptom is pain in the distribution of the sciatic nerve" [58], or the name given to "a multitude of conditions which give rise to pain in the distribution of the sciatic nerve and its branches" [58]. The sciatic nerve proper is distributed to the posterior and lateral aspects of the leg and to the foot [28]. (See Figure 1.)

None of the four groups of nerves that supply the gluteal region comes from the sciatic trunk, yet our records (Table I) show that this is the region most frequently affected by sacrarthrogenetic telalgia. The posterior femoral region (sciatica), the lateral femoral region (crural neuralgia), the sacral region (sacralgia), the inguinal region (lumbo-

* The other four articles, now in preparation and to be published under the same title, deal with the following phases of the subject:
II. Sacral Mobility;
III. Alternating Scoliosis;
IV. Diagnosis;
V. Treatment.

abdominal neuralgia), and the genital region (genital neuralgia) are not included in the distribution of the sciatic nerve, but commonly are affected by sacrarthrogenetic telalgia. If one should enlarge the foregoing definitions and add "and in the distribution of the posterior femoral cutaneous (small sciatic) nerve", sciatica might be considered to include the inferior gluteal region, the posterior femoral region, and portions of the scrotum, but still it would not cover several of the areas to which sacrarthrogenetic telalgia commonly is referred. Furthermore, in any large series of cases, an affection of the trunk of a nerve should involve all portions of that nerve's distribution, and, although the plantar type of sciatica is said to be intensely painful [71], none of our case records shows telalgia affecting the sole of the foot. Finally, Oppenheim has said: "Sciatica generally holds to the course of one nerve so that the patient can *trace the whole pain tract with his finger*", but, despite our every effort to obtain accurate localization of pain in each case, our patients' answers indicate that areas of telalgia are likely to be wide-spread and not sharply delimited. If sacrarthrogenetic telalgia regularly involves areas beyond the boundaries of the sciatic distribution, consistently shuns certain sciatic territory, and is difficult to localize, then the terms "sciatica" and "sacrarthrogenetic telalgia" are not synonymous and should be divorced.

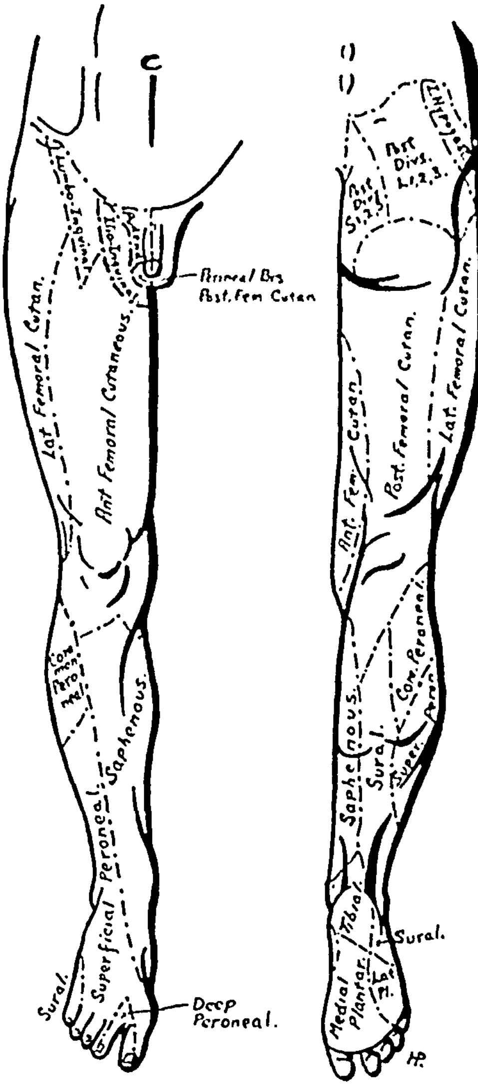

FIG. 1

Distribution of the cutaneous nerves in the buttock and lower extremity.[28]

Inaccurate nomenclature inevitably has led to inaccurate conceptions of the origin of sacrarthrogenetic telalgia. Thus the second great source of confusion is the direct result of the first and is found in the attempts of many authors to explain the referred pain on the basis of direct pressure *, or other irritating stimuli applied to the sciatic nerve, the sacral plexus, or the individual nerve roots from which they are formed.

* Among those who took this view are: Baer, Bauman, Chapman, Cox, Dunlop, Freiberg, Freiberg and Vinke, Goldthwait and Osgood, Haglund, Jackson, McClure, Meisenbach, Nutter, Peckham, Pitfield, Ridlon and Berkheiser, Ryerson, Sachs, Winsor, Yeoman, and Young. (See Bibliography.)

It seems reasonable to us to suppose that spasm of the piriformis and other muscles occasionally may cause pressure upon the sciatic trunk and so produce the syndrome of irritation or compression of a peripheral nerve *, although Schüdel has stated that the piriformis, when contracted, bridges and protects the sciatic nerve. We do not doubt that inflammation†, extending from the sacro-iliac joints and other structures that lie in close proximity to the lumbosacral cord and sacral plexus, may cause similar disturbances. We have seen a number of cases of radiculitis and funiculitis apparently caused by spondylitic (Danforth and Wilson, Verrall, and Williams), spondylo-arthritic (Craig and Ghormley, Goldthwait, Putti, and Rogers), or spondylolisthetic narrowing (Johnson, Mitchell, Smith, Von Lackum, and Williams and Yglesias) of the intervertebral foramina. But, if we exclude the occasional case of reflex physiopathy [2], we cannot agree with the assumption that pressure upon a nerve root, plexus, or trunk may cause pain in areas not supplied by those structures. The regions most frequently affected by sacrarthrogenetic telalgia (Table I) are supplied by peripheral nerves derived from both the anterior and the posterior divisions of every spinal nerve from the first lumbar segment to the third sacral segment. To account for the referred pain on the basis of direct pressure, one must predicate either an ascending or a reflex irritation, a widespread lesion, or a lesion at the level of the first lumbar segment [45]. It seems incredible to us that lesions of any one of these types regularly should fail to involve those portions of the third and fourth lumbar nerves that supply the internal crural region, yet none of our patients has complained of telalgia in the distribution of the

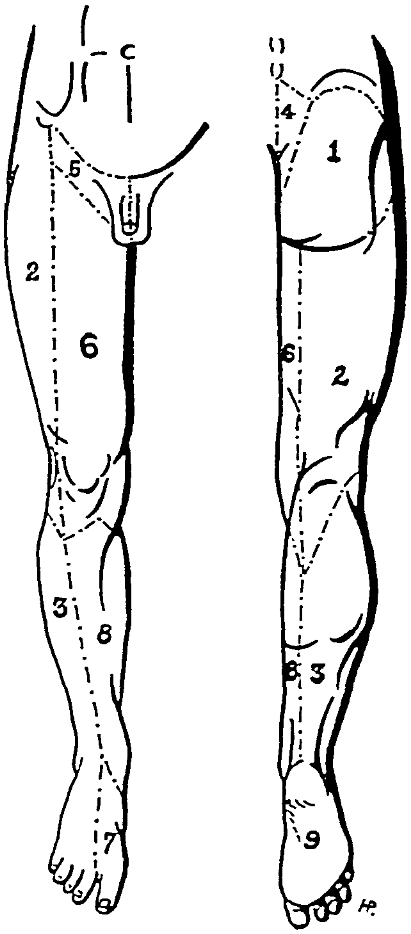

Fig. 2

Suggested division of the buttock and lower extremity into regions for purposes of history-taking in sacrarthrogenetic telalgia.

* This theory was supported by such authors as: Babinski, Barshinger, Bradford and Brackett, Cofield, Ehret, Freiberg and Vinke, Guse, Heald, Kleinberg, Roberts, and Yeoman.

† Among those who attributed the cause to inflammation are: Blencke, Chapman, Cyriax, Frauenthal and Finkelstein, Grossman and Keschner, Key, Maclean, Miltner and Lowendorf, Plate, Rogers, Ryerson, Thornton, Williams, and Yeoman.

TABLE I

CLASSIFICATION OF SACRARTHROGENETIC TELALGIA BY ANALYSIS OF 404 RECORDS OF TELALGIA FOUND IN

Region	Area of Telalgia	Cutaneous Innervation of Area
1.	Buttock (and Intergluteal Triangle)	*Posterior divisions of lumbar I, II, III.* Posterior divisions of sacral I, II, III. Iliohypogastric from lumbar I. Gluteal branches of posterior femoral cutaneous *from sacral I, II, III.*
2.	Thigh and/or Knee (Posterior and/or Lateral)	Iliohypogastric from lumbar I. Lateral femoral cutaneous from lumbar II, III. Posterior femoral cutaneous from sacral I, II, III.
3.	Leg (Posterior and/or Lateral) and/or Dorsolateral Foot and/or Last Four Toes	Common peroneal from lumbar IV, V; sacral I, II. Superficial peroneal from lumbar IV, V; sacral I. Sural from sacral I, II.
4.	Intergluteal Triangle Only	Posterior divisions of lumbar IV, V. Posterior divisions of sacral I, II, III.
5.	Groin and/or Genitalia	Ilio-inguinal from lumbar I. Lumbo-inguinal from lumbar I, II. Perineal branches of posterior femoral cutaneous from sacral I, II, III. Pudendal from sacral II, III, IV.
6.	Thigh and/or Knee (Anterior and/or Medial)	Anterior femoral cutaneous from lumbar II, III.
7.	Foot (Dorsal and/or Medial) and/or Great Toe	Superficial peroneal from lumbar IV, V; sacral I. Deep peroneal from lumbar IV, V.
8.	Leg (Anterior and/or Medial)	Saphenous from lumbar III, IV.
9.	Foot (Sole)	Plantar: medial from lumbar IV, V; lateral from sacral I, II. Tibial from sacral I, II.

* Telalgia in the sacral region (Region 4) is listed separately only when no other region is involved, because of the difficulty that we experienced in distinguishing it from gluteal telalgia. All cases in which there were changes in reflexes, or sensation, or tenderness of the trunks of peripheral nerves have been rigidly excluded.

TABLE I—*Continued*

REGIONS,* INNERVATION OF THESE REGIONS, AND 506 EXAMINATIONS FOR LOW-BACK DISABILITY

Derived from Spinal Nerves		Dermatomes		Telalgia		
				Cases **		Pain †
Anterior Divisions	Posterior Divisions	Anterior	Posterior	*No.*	*Per Cent.*	*Per Cent.*
Lumbar I Sacral I, II, III	Lumbar I, II, III Sacral I, II, III	Lumbar I Sacral I, II, III	Lumbar I, II, III Sacral I, II, III	357	88.0	43.0
Lumbar I, II, III Sacral I, II, III		Lumbar I, II, III Sacral I, II, III		218	54.0	26.0
Lumbar IV, V Sacral I, II		Lumbar V Sacral I, II		114	28.0	14.0
	Lumbar IV, V Sacral I, II, III		Lumbar IV, V Sacral I, II, III	(68)	(17.0)	(8.0)
Lumbar I, II Sacral I, II, III, IV		Lumbar I Sacral III		52	13.0	6.0
Lumbar II, III		Lumbar II, III		16	4.0	2.0
Lumbar IV, V Sacral I		Lumbar V (Sacral I)		12	3.0	1.0
Lumbar III, IV		Lumbar IV		0	0	0
Lumbar IV, V Sacral I, II		(Lumbar V) Sacral I		0	0	0

** In these 404 cases, 837 regions were involved, an average of 2.1 regions per case.
† This heading refers to the incidence of pain in any given region as compared with the total incidence of pain in all regions.

saphenous nerve. Finally, motor and sensory changes regularly are associated with compression of nerves [80], but motor and sensory changes are conspicuously absent in telalgia. Sensory and trophic changes are to be *expected in cases of irritation of nerves* [80], *but the* vasomotor and sudomotor disturbances which frequently are noted in telalgia are not associated with objective sensory changes, and, when atrophy is present, the electrical reactions are normal. Therefore, these changes belong to the functional groups of reflex physiopathic disturbances and phenomena of disuse. *Sacrarthrogenetic telalgia is not the result of compression or irritation of the trunks of peripheral nerves.*

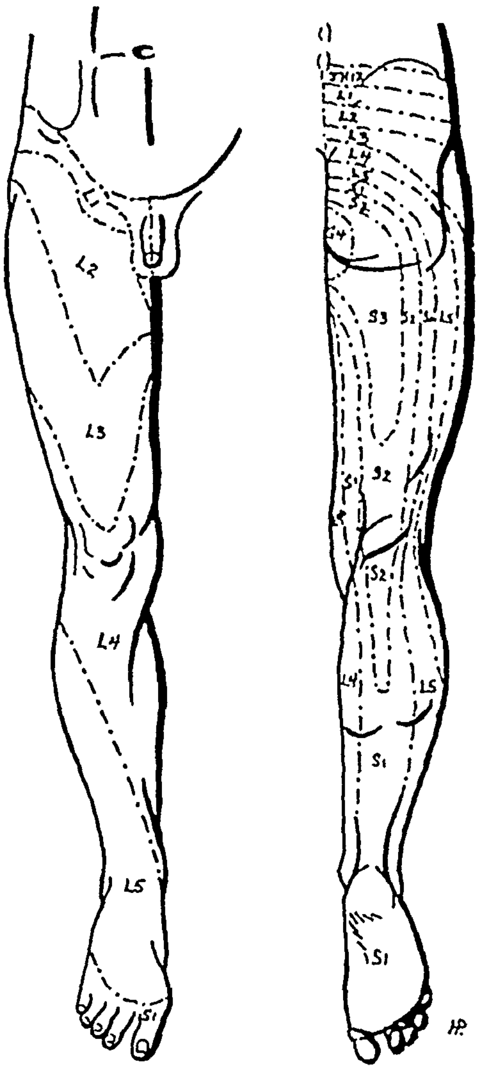

FIG. 3

Dermatomes of the lower extremity, as represented by those who follow Head's teachings.[38]

The evidence adduced by several authors to explain sacrarthrogenetic telalgia on a segmental basis has been summarized by Miltner, and will not be repeated here. Head wrote: "*Where a painful stimulus is applied to a part* of low sensibility in close central con*nection with a part of much greater* sensibility, the pain produced is felt in the part of higher sensibility rather than in the part of lower sensibility to which the stimulus was actually applied". The external surface of the body is, of course, the "part of higher sensibility", but a third source of confusion appears when we attempt to delineate the segmental spinal sensory areas, or dermatomes, in the lower extremities. By the wide divergence of opinion expressed therein, the literature reflects the present impossibility of defining these dermatomic areas with sufficient accuracy to allow one diagram to fit all cases. Most of the diagrams can be fitted into one of two groups: those which follow Head's teachings (Fig. 3), and those which follow Dejerine's (Fig. 4). To avoid controversy, we have classified our records of telalgia by regions (Fig. 2). This is convenient because it groups certain contiguous dermatomes, the exact location of which has been a source of confusing argument. For example: those authors who would show that pressure upon the emerging fifth lumbar funiculus is responsible for pain referred to the lateral aspect of the leg[18] have reproduced the diagrams of several authorities to prove that

this is the normal location of the fifth lumbar anterior (ventral) dermatome (Fig. 3). Those who ascribe such pain to lesions of the sacro-iliac joint[77] have found other authorities to prove that the lateral crural region is a part of the first and second sacral anterior dermatomes (Fig. 4).

In the inquiry at hand, the upper sacral joints represent the "part of lower sensibility", but the determination of their innervation is the fourth and greatest source of confusion that we have encountered. Many anatomists ignore the problem entirely.* Few of them illustrate their dissections. Those who describe the innervation of these joints usually group each joint and its far-flung ligaments as a unit, and, so far as we have been able to determine, only Rüdinger and Smith-Petersen have reported dissections of the innervation of each individual articulation and ligament. The sacro-iliac joint usually is said to be supplied thus:

1. Anteriorly, by direct branches of the lumbosacral cord which is derived from the anterior divisions of the fourth and fifth lumbar nerves;**

2. Inferiorly, by branches of the superior gluteal nerve which is derived from the anterior divisions of the fourth and fifth lumbar nerves and the first sacral nerves;†

3. Posteriorly, by direct branches of the posterior primary divisions of the first and second sacral nerves:

4. By branches of the obturator nerve which is derived from the anterior divisions of the second, third, and fourth lumbar nerves;‡

5. By branches of the pelvic portion of the sympathetic gangliated cord.

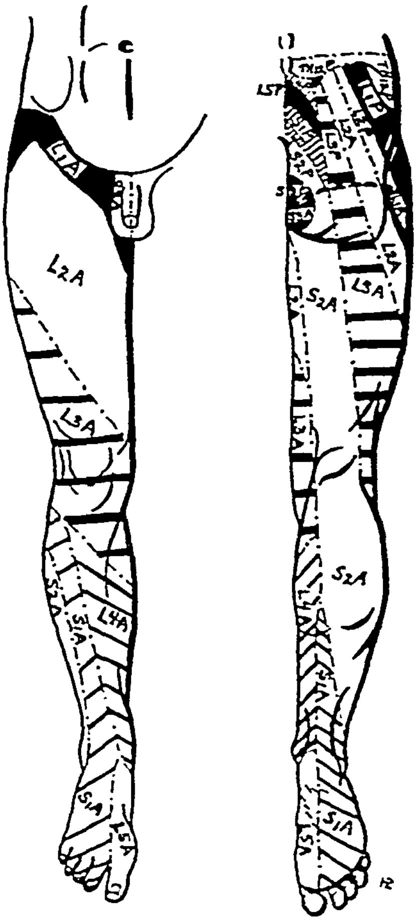

FIG. 4

Dermatomes of the lower extremity, as represented by those who follow Dejerine's teachings.[42]

* In such standard anatomical texts as Cunningham, Gray, Piersol, and Spalteholz, we could find no description of the innervation of the upper sacral joints.

** In a monograph in which he described and illustrated his careful dissections of the innervation of every joint in the body, Rüdinger stated that he could find no nerves to the sacro-iliac joint on its anterior aspect, but only branches of the posterior divisions of the sacral nerves on the posterior aspect.

† Quain and Wilson illustrated a small branch of the superior gluteal nerve running to the posterior-inferior iliac spine. Those authors who include this innervation usually state that these branches accompany the nutrient vessels into the ilium.

‡ Hilton seems to have been the first to describe this innervation; Von Bardeleben followed him; Testut quoted Hilton, but did not verify this source of supply; Morris and later authorities entirely omitted the obturator nerve.

The sacrolumbar joint usually is said to be supplied thus:

1. By direct branches of the fourth and fifth lumbar nerves; *
2. By branches of the lumbar portion of the sympathetic gangliated cord.

These descriptions led Smith-Petersen and others (Cowan, Harris, and Pitfield) to conclude that pain from the sacrolumbar joint should be referred only to the last two lumbar dermatomes (Fig. 4). They concluded also that pain from the sacro-iliac joint should be referred to the last two lumbar and first two sacral dermatomes, with additional radiation along the courses of the superior gluteal and obturator nerves. Head's rule indicates that painful stimuli from the upper sacral joints should travel centrally in the anterior divisions of the last four lumbar nerves and first sacral nerve and in the posterior divisions of the first two sacral nerves. Thus, the referred pain should affect the last four lumbar anterior dermatomes and first sacral anterior dermatome, as well as the first two sacral posterior dermatomes **. However, sacrarthrogenetic telalgia regularly fails to involve the fourth lumbar anterior dermatome (Table I) and only rarely involves the second and third lumbar anterior dermatomes. To explain genito-inguinal telalgia, Smith-Petersen concluded that, while some of the painful stimuli are referred to dermatomes, others are referred as a neuralgia to the course of the trunk of the obturator nerve. Head's rule offers no explanation for telalgia in the first lumbar anterior dermatome and third sacral anterior dermatome. We have not found any author who explained the production of widely different patterns of pain, within a few minutes or hours, by the same lesion in the same patient, or who investigated the reasons why sacrarthrogenetic telalgia affects certain portions of its usual distribution more frequently than others. Therefore, we decided that a more exact determination of the innervation of the individual elements of the upper sacral joints and their ligaments was necessary.

Our dissections of four cadavera led us to agree with Rüdinger's findings. (See Figure 5.) The innervation of the capsule of each sacrolumbar articular facet is derived from the posterior division of the fifth lumbar nerve which passes close to the articulation on its way to the multifidus muscle. The lateral branch of the fifth lumbar posterior division communicates with the corresponding element of the fourth lumbar nerve and with the posterior sacral plexus. This plexus is formed by the lateral branches of the posterior divisions of the first three sacral nerves and sends a communicating loop to the posterior division of the fourth sacral nerve. The plexus lies deeply imbedded in the dense sacro-iliac and sacro-ischial ligaments and is separated from the sacrum by a thin layer of ligaments

* Almost all authorities agree on this innervation, but, like Mitchell, they neither state the exact supply of the articular facet as distinct from the joint as a whole nor differentiate between the anterior and posterior divisions of these nerves.

** The posterior (dorsal) dermatomes are well described by Tilney and Riley, but are too narrow to be of much use in differential diagnosis; indeed confusion may arise from the fact that the posterior margin of the sacro-iliac joint lies directly in front of the fifth lumbar posterior dermatome. The fourth and fifth lumbar dermatomes and the first sacral posterior dermatome are not continuous with the corresponding anterior dermatomes in the lower extremity. There are no posterior dermatomes in the lower extremity.

TABLE II

A MORE DETAILED ANALYSIS OF THE 404 CASES RECORDED IN TABLE I

Region	Unilateral Pain			Bilateral Pain			Pain All Types			Expectancy †	
	Cases		Pain*	Cases		Pain*	Cases		Pain*	Impulses	Pain
	No.	*Per Cent.*	*Per Cent.*	*No.*	*Per Cent.*	*Per Cent.*	*No.*	*Per Cent.*	*Per Cent.*	*No.*	*Per Cent.*
1.	201	84.0	41.0	156	94.0	45.0	357	88.0	43.0	84	43.0
2.	154	64.0	31.0	64	39.0	19.0	218	54.0	26.0	38	20.0
3.	78	33.0	16.0	36	22.0	10.0	114	28.0	14.0	30	15.0
4.	(16)	(7.0)	(3.0)	(52)	(32.0)	(15.0)	(68)	(17.0)	(8.0)	(10)	(5.0)
5.	36	15.0	7.0	16	10.0	5.0	52	13.0	6.0	6	3.0
6.	4	2.0	1.0	12	7.0	3.0	16	4.0	2.0	8	4.0
7.	4	2.0	1.0	8	5.0	2.0	12	3.0	1.0	6	3.0
8.	0	0	0	0	0	0	0	0	0	0	0
9.	0	0	0	0	0	0	0	0	0	12	6.0
Total	493 (239 patients)	207.0	100.0	344 (165 patients)	209.0	99.0	837 (404 patients)	207.0	100.0	194	99.0

* This heading refers to the incidence of pain in any given region as compared with the total incidence of pain in all regions.

† See footnote to page 124 for method of calculating the expectancy of referred pain for each region.

and periosteum. It distributes branches from the fifth lumbar nerve and from the first two sacral nerves to the interosseous sacro-iliac ligaments and the sacro-iliac joint.

Thus painful stimuli arising within the sacrolumbar zygapophysial articulations must travel centrally in the posterior divisions of the fourth and fifth lumbar nerves. Painful stimuli arising within the sacro-iliac articulation must travel centrally in the posterior divisions of the fifth lumbar nerve and first and second sacral nerves. Therefore, each articulation has a "close central connection" only with the posterior dermatomes (Fig. 4). *Telalgia in the posterior dermatomes of the sacral region is caused by intra-articular lesions of the upper sacral joints and frequently persists after radiation to the anterior dermatomes in the lower extremities has ceased.***

** The same mechanism that produces pain in these posterior dermatomes conceivably might be responsible, by an intrasegmental transmission of stimuli, for pain referred to the fifth lumbar and first and second sacral anterior dermatomes in the lower extremity. Still we have not explained the telalgia in the major portion of the buttock, in the lateral femoral region, in the anterior femoral region, or in the groin. Therefore, we must search

The dense fibrous tissue, generically known as tendon, by which the contractile substance of each muscle is attached to the skeleton or other structures, phylogenetically represents a portion of the original muscle converted into connective tissue [61] and is innervated by twigs of the nerves that ramify within the substance of that muscle [9]. By such myomeric degeneration, the sacrotuberous and long posterior sacro-iliac ligaments were formed [53] as direct continuations of the tendinous origin of the semitendinosus and the long head of the biceps femoris muscles. The common aponeurotic tendons of the sacrospinalis and gluteus maximus muscles, which blend with the posterior sacro-iliac and sacrotuberous ligaments, similarly represent portions of those muscles which have undergone tendinous degeneration. The anterior sacro-iliac and lumbosacral ligaments are direct continuations of the fibers of origin of the iliacus muscle from the transverse processes of the last lumbar and the first three sacral vertebrae. They are analogous to the intertransverse ligaments [53] and tendinous origins of the psoas and quadratus lumborum muscles from the transverse processes of the lumbar vertebrae. The accessory ligaments of the upper sacral joints are not exceptions to the general rules governing the innervation of similar structures throughout the body, but actually receive nerve fibers from the muscles to which they afford attachment. We have been able to trace in autopsy material, by histological sections *, the course of nerve fibers that pass from the muscles to end in these ligaments. Such nerve fibers are scarce, as they are elsewhere in tendinous tissue, but they undeniably are present, and their very scarcity adds to the qualifications of these ligaments as "parts of low sensibility".

The iliolumbar ligaments, which act as a hammock for the fifth lumbar vertebra [46], afford partial origin to the sacrospinalis and multifidus muscles. Thus they have access to muscular twigs from the posterior divisions of all the five lumbar and the first three sacral nerves (Table III). Painful stimuli that travel centrally in these nerves may appear as telalgia in the corresponding posterior dermatomes (Fig. 4). Each iliolumbar ligament also receives twigs of nerves from the quadratus lumborum and iliacus muscles, thus establishing a direct central connection with the first, second, and third lumbar anterior dermatomes.

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for a direct connection between the ligaments [8] of the upper sacral joints and the anterior divisions of the lumbar and sacral nerves in order to establish a "close central connection" with the anterior dermatomes. A clue to this connection is found in Partridge's restatement of Hilton's law: "No joint is moved by any muscle whose nerve does not also supply a twig to that joint, and all the nerves which supply a moveable joint are branches of the nerves which supply the muscles moving the joint, and their distribution is on that surface of the joint which is controlled by those muscles." If the sacro-iliac joint obeyed this law, its ligaments should receive nerves from every muscle that attaches to the pelvis or sacrum, and its articular nerves presumably would be so numerous or so large that they would be dissected and described by every anatomist. Apparently the term "movable joint" was inserted into the law in an attempt to exclude the sacro-iliac joints, and Partridge did not state any corollary which covers them.

* The gross anatomical research presented in this paper was done by one of us in the Department of Anatomy of the University of California; the histological work, in the Department of Pathology of the University of California Medical School. The illustration of the gross dissections was made by a staff artist in the Art Department of the University of California Medical School.

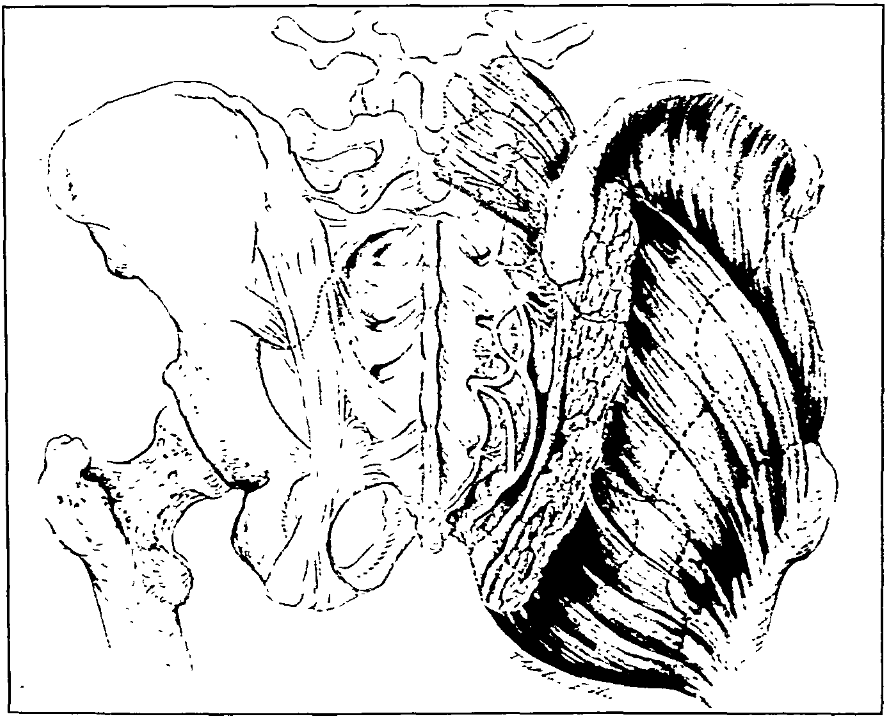

Fig. 5
The posterior sacro-iliac and sacro-ischial ligaments (left). The posterior sacral plexus and the innervation of the sacrolumbar and sacro-iliac articulations (right).

The sacrolumbar and anterior sacro-iliac ligaments give origin to only one muscle,—the iliacus. Through the anterior divisions of the second and third lumbar nerves these ligaments have a direct central connection with the corresponding anterior dermatomes.

The posterior sacro-iliac and sacro-ischial ligaments have access to four different types of innervation:

1. Direct branches from the posterior sacral plexus (fifth lumbar posterior division to third sacral posterior division), which are given off by the common cord as it descends to pierce or to curve around the inferior margin of the gluteus maximus muscle (Fig. 5).

2. Twigs from the origins of the sacrospinalis and multifidus muscles (first lumbar posterior division to third sacral posterior division).

3. Probably some small direct branches from the anterior division of the fourth sacral nerve, when it pierces the sacrotuberous ligament.

4. Twigs from the origins of the gluteus maximus, piriformis, biceps femoris (long head), and semitendinosus muscles (fifth lumbar anterior division to third sacral anterior division).

Thus the posterior sacro-iliac and sacro-ischial ligaments have a close central connection with the first three sacral posterior dermatomes and all of the five lumbar posterior dermatomes, with the fifth lumbar an-

TABLE III

THE INNERVATION OF THE SACRO-ILIAC, ILIOLUMBAR, AND SACRO-ISCHIAL LIGAMENTS[23]

Ligament	Original Muscle	Ligamentous Surface	Local Innervation	Spinal Nerve: Posterior Division	Spinal Nerve: Anterior Division
Iliolumbar	Iliacus	Superior Anterior	Femoral		Lumbar II, III
	Quadratus lumborum	Superior	Direct		Lumbar I
	Sacrospinalis	Posterior	Direct	Lumbar I to V	
	Multifidus	Posterior	Direct	Lumbar III, IV, V Sacral I, II, III	
Anterior Sacro-Iliac Anterior Sacrolumbar	Iliacus	Anterior	Femoral		Lumbar II, III
Short Posterior Sacro-Iliac			Posterior sacral plexus	Lumbar V Sacral I, II	
	Gluteus maximus	Posterior	Inferior gluteal		Lumbar V Sacral I, II
Long Posterior Sacro-Iliac	Sacrospinalis	Posterior	Direct	Lumbar I to V	
	Multifidus	Posterior	Direct	Lumbar III, IV, V Sacral I, II, III	
Sacrospinous			Posterior sacral plexus	Sacral I, II, III	
	Piriformis[25]	Anterior	Direct		Sacral I, II
Sacrotuberous			Posterior sacral plexus	Sacral I, II, III	
	Piriformis	Anterior	Direct		Sacral I, II
	Gluteus maximus	Posterior and lateral	Inferior gluteal		Lumbar V; Sacral I, II

TABLE IV

Analysis of 330 Cases in Which Tenderness was Found in 506 Examinations for Low-Back Disability

Point of Tenderness	Cases * No.	Cases * Per Cent.	Tenderness Per Cent.
Lumbosacro-iliac angle	252	76.0	28.0
Posterior iliac interspinous notch	249	75.0	27.5
Lesser sacrosciatic notch	184	56.0	20.0
Sacrotuberous ligament (free edge)	118	36.0	13.0
Sacrolumbar interspinous ligament	42	13.0	5.0
Sacral interspinous ligaments	31	9.0	3.0
Sciatic trunk in thigh	17	5.0	2.0
Iliolumbar ligament at iliac crest	12	4.0	1.0

* In these 330 cases, there were 905 tender points, an average of 2.7 tender points per case.

terior dermatome and the first three sacral anterior dermatomes, and probably with the fourth sacral anterior dermatome.

To recapitulate: *Pain may be referred from the sacrolumbar zygapophysial articulation to the fourth and fifth lumbar posterior dermatomes; from the sacro-iliac articulation to the fifth lumbar and first and second sacral posterior dermatomes; from the iliolumbar ligament to all of the five lumbar and the first three sacral posterior dermatomes, as well as to the first three lumbar anterior dermatomes; from the sacrolumbar and anterior sacro-iliac ligaments to the second and third lumbar anterior dermatomes; from the posterior sacro-iliac and sacro-ischial ligaments to all of the five lumbar and the first three sacral posterior dermatomes, as well as to the fifth lumbar and the first three (or four) sacral anterior dermatomes.*

It should be noted that none of these structures has a close central connection with the fourth lumbar anterior dermatome, and there seems to be no controversy over the location of this dermatome in the anterior crural region (Figs. 3 and 4). None of our patients has complained of telalgia in this region.

Only the posterior sacro-iliac and sacro-ischial ligaments have close central connections with the dermatomes in the lateral crural region. This finding tends to emasculate the arguments concerning the location of the fifth lumbar anterior dermatome and the first and second sacral anterior dermatomes.

Less easy to explain is the fact that none of our patients has com-

plained of pain referred to the sole of the foot. A majority of the authorities represent the plantar region as the first sacral anterior dermatome, which has a close central connection with the posterior pelvic ligaments. Our only explanation of this phenomenon is that the thickened skin of the sole of the foot may not qualify as a "part of much greater sensibility" to pain than the pelvic ligaments.*

Many allegedly tender anatomical structures have been described in cases of sacrarthrogenetic telalgia. Because we have found in these descriptions a fifth source of confusion, we have limited our palpation and records of tenderness to eight easily recognizable landmarks (Table IV) which include the accessible portions of all the posterior ligaments of the upper sacral joints. The lumbosacro-iliac angle and the posterior iliac interspinous notch show the two highest percentages of tenderness in this group, and the latter presents the obvious diagnostic advantage of containing fewer anatomical structures to confuse the examiner.** Furthermore, it appears that the free edge of the sacrotuberous ligament above and medial to the ischial tuberosity was found to be tender in more than one-third of our cases. Because of the relative isolation of the ligament at this point, the possibility of confusing such tenderness with that of other anatomical structures is minimal. We have found, as have others [13, 37], that pressure upon some one of these tender spots occasionally produces or aggravates the telalgia of which the subject complains. When pressure upon the free edge of the sacrotuberous ligament causes this phenomenon, as it has done in several of our cases, strong presumptive evidence is produced to show that the ligaments are the source of the referred pain.

CASE REPORTS

CASE 1. M. M., a white girl, nineteen years of age, complained of sacral backache of nineteen days' duration. The pain was vague at onset, non-radiating, constant, dull, and aching in character. It was somewhat relieved by lying on the right side. It was

* It is interesting to note that, if our theory is carried to its logical conclusion, it should be possible to anticipate the frequency with which sacrarthrogenetic telalgia will affect any given region. This we have done, and it appears that the expectancy of referred pain for each region shows more than a casual relationship to the actual experience (Table II). The expectancy was calculated as follows: We assumed that a single painful stimulus could be applied with equal intensity to each individual part of the upper sacral joints and their ligaments (Table III). The number of impulses so generated in each primary division of the spinal nerves was tabulated and reduced to a percentage of the total for all regions (except Region 4). This value was considered to be the expectancy for the corresponding dermatomes, and the expectancy for each region was computed as the sum of the values of its component dermatomes. Thus, without attacking the complex problem of the intrasegmental and intersegmental spread of stimuli through intercalated cells, we arrived at the figures shown in the last column of Table II, with one exception. The clinical figures for Region 4 represent those patients who had no pain except that in the intergluteal triangle, and, since the only structures which can produce telalgia in the sacral region without causing other radiation are the sacrolumbar and sacro-iliac articulations, the expectancy for this region alone is the sum of the impulses from the joints proper, reduced to a percentage of the total value of all other regions. The greatest discrepancy between experience and expectancy is 6 per cent., and it would seem that a larger experience might make the comparison even more striking.

** The structures affected by pressure applied over the interspinous notch are: the skin and subcutaneous tissue, the gluteus maximus muscle, the long posterior sacro-iliac ligament, and those portions of the short posterior sacro-iliac and sacrotuberous ligaments that attach to the posterior-inferior iliac spine.

aggravated by all motions of the trunk or legs, by coughing or sneezing, by riding in automobiles, and by missteps.

Family History: The mother had died of pulmonary tuberculosis when the patient was three years old.

Past History: The patient had spent two brief periods in sanatoria (one at the age of thirteen and another at the age of sixteen) for a tuberculous lesion of the left apex, which was said to have been arrested.

Physical Examination: The mouth temperature was 99 degrees. The pulse was 72; the respirations, 20 per minute. The patient was a well-developed and well-nourished girl of the slender anatomical type, who stood in fair posture with the right knee semiflexed. With both knees straight, she showed a decrease in the normal lumbar lordosis, a total left lateral scoliosis, with a list of the trunk to the right, and a rotation of the left shoulder and left buttock backward behind the plane of the heels. She carried the right shoulder and right buttock lower than the left. There was marked spasm of the right sacrospinalis muscle. Palpation revealed almost no tenderness anywhere. Percussion of the sacrum and compression of the iliac crests aggravated the sacral backache. All motions of the spine and right hip were guarded. Straight-leg raising on the left was 80 degrees; on the right, 50 degrees. Prone knee flexion[62] lacked three inches on the left and twelve inches on the right. The lower extremities were equal in length and circumference. The planes of the anterior-superior and posterior-superior spines of each ilium were symmetrical and were inclined forward 10 degrees on either side. There was dullness with distant respiratory sounds and vocal resonance and diminished fremitus at the left apex, but no râles.

Rectal Examination: Some tenderness was found high up toward the sacro-iliac joint on the right.

Roentgenographic Examination: Scarring and pleural thickening were seen at the left apex. There was some faint cloudiness of the right sacro-iliac joint.

Laboratory Examination: A Wassermann test was negative. An intradermal tuberculin test (Atsatt) was positive up to and including a dilution of 1:10,000. The blood showed:

Red blood cells—4,200,000
White blood cells—9,800
  Polymorphonuclears—64 per cent.
  Lymphocytes—30 per cent.
  Mononuclears—4 per cent.
  Eosinophiles—2 per cent.

Diagnosis: Tuberculous arthritis of the right sacro-iliac joint. Healed pulmonary tuberculosis of the left upper lobe.

Advice: Arthrodesis of the right sacro-iliac joint. (This was refused by the father.)

Course: Immediate treatment included hospitalization, a bed on the roof, heliotherapy, and the application of a plaster spica from the toes on the right and the knee on the left to the nipple line. Some relief from pain was obtained by the application of local heat to the right sacro-iliac region through a window in the cast. Ten days after admission, the patient developed telalgia in the right anterolateral femoral region, which steadily increased in severity for three days. On the third day, the patient also complained of telalgia in the right buttock, posterior femoral region, and calf. Shortly thereafter all pain disappeared rapidly and was gone within an hour. A roentgenogram, taken two weeks after entry (the day after the pain had disappeared), showed an early destructive lesion in the anterior margin of the right sacro-iliac joint. The patient rapidly developed a large abscess in the right iliac fossa, which eventually pointed in the groin and was aspirated three times. Aerobic and anaerobic cultures of the pus from this abscess showed no growth, but a guinea-pig, inoculated with one of these specimens, developed typical tuberculous lesions. Suddenly, ninety-six days after admission, the patient died. The apparent cause of death was pulmonary embolism, but post-mortem examination was denied us by the father.

This case seems to show that an early tuberculous lesion in the sacro-iliac joint caused pain referred only to the sacral region. The pressure of the pus within the joint was transmitted at first to the weak anterior ligaments and caused telalgia in the second and third lumbar anterior dermatomes. When the pressure within the joint became extreme, it was transmitted to the strong posterior ligaments and caused a transient radiation to the first and second sacral anterior dermatomes. When the anterior capsule finally was ruptured, relief from telalgia was prompt, and the pain did not recur during the rest of the course of the disease.*

CASE 2.** G. McN., a white boy, aged ten years and five months, complained of pain in the right buttock, of eight days' duration. The onset of pain was acute, with fever. The pain was non-radiating; it had become steadily more severe since onset; it was aggravated by turning in bed, by lying prone or on the right side; and it was relieved by nothing. *Three days after the onset, numerous minute red spots appeared on the patient's chest and abdomen*, but he did not complain of tender fingers or toes.

Physical Examination: The patient was a well-developed and well-nourished boy whose general physical examination was negative, except as noted. The mouth temperature was 100.2 degrees. The pulse was 100; the respirations, 22 per minute. The cheeks were flushed, and the skin was hot. There were petechial spots on the chest and abdomen. The boy could not stand without support. He bore his entire weight upon the left leg, with the right knee bent, and showed a marked list of the trunk to the right. *All the lumbar muscles were in extreme spasm, and there was an accentuation of* the normal lumbar lordosis. Tenderness was maximal over the upper two-thirds of the right sacro-iliac joint. Supine hip-and-knee flexion was performed normally. Straight-leg raising was 45 degrees on the left, 35 degrees on the right. Hyperextension of the right hip was not possible. Compression of the iliac crests caused immediate *excruciating pain in the right sacro-iliac joint and, occasionally, in the lower portion of the* right buttock where there was no direct tenderness. The lower extremities were equal in length and circumference. All of the deep reflexes were diminished in the right lower extremity and were slightly hyperactive in the left where there was a tendency toward ankle clonus.

Rectal Examination: There was tenderness high up toward the sacro-iliac joint on the right.

Roentgenographic Examination: There was a slight cloudiness of the right sacro-iliac joint space.

Laboratory Examination: A Wassermann test was negative, as was the Atsatt tuberculin test. The blood showed:

Red blood cells—4,600,000
Hemoglobin—90 per cent.
White blood cells—16,000
Polymorphonuclears—79 per cent.

Diagnosis: Septicaemia with acute (suppurative?) arthritis of the right sacro-iliac joint.

Course: On the day after admission, the patient's temperature rose to 104 degrees. On the second day, *there was a marked amelioration of symptoms*, and the white blood count increased to 17,000 with a differential count of 90 per cent. polymorphonuclear leukocytes. It was decided that the focus had drained spontaneously, and that surgery should be delayed until a localized abscess had developed in the soft tissues. For two

* Heath reported three cases of "sacro-iliac disease" (tuberculosis) in each of which pain was relieved by aspiration of an abscess.

** For permission to use this case report, the authors are indebted to Dr. Robert B. Osgood, on whose Service in the Children's Hospital, Boston, Massachusetts, this patient was treated.

weeks the patient continued to improve. A subsequent roentgenogram showed a destructive lesion in the right sacro-iliac joint, with widening of the joint and some proliferation of new bone. On the fifteenth day after admission, there was a recurrence of pain in the right buttock, an elevation of the temperature to 102.8 degrees, and the white blood count rose from 10,000 to 18,000. Two days later Dr. Ober explored the right buttock. Considerable oedema of the soft tissues was found, but no abscess. The iliac bone opposite the lower half of the sacro-iliac joint was soft and necrotic. When a triangular section of this bone had been removed, it was seen that the joint cartilage on its deep surface was necrotic and flaking away. There was also some involvement of the contiguous sacral cartilage, but there was no pus. Cultures of the excised bone showed a profuse and uncontaminated growth of staphylococcus albus. The wound was drained. Convalescence was uncomplicated, and the child was sent to the Wellesley Convalescent Home one month after operation. The case was followed for fifteen months. No recurrence of symptoms was noted.

Plagemann reported a case of acute suppurative osteo-arthritis involving the right sacro-iliac joint in a boy of nineteen years. This case is very similar to ours except that, in addition to the pain in the right gluteal region, there was also pain radiating to the right thigh (we do not know the exact region). A focus of pus and granulation tissue was removed surgically from the sacral surface of the right sacro-iliac joint. In our case, an almost identical lesion which did not go on to pus formation caused pain referred only to the upper gluteal region. These cases seem to show that even acute *intra-articular lesions do not cause pain to be referred to the anterior dermatomes unless they can produce an increase in the tension of the extra-articular ligaments.*

Case 3. J. K., a white man, thirty years of age, sustained a crushing injury to the pelvis when the main pole of a hay derrick fell upon him. At the time of our examination, six weeks after the accident, he complained of pain in both buttocks, in the right posterior and lateral femoral regions, and in the right groin.

Roentgenographic Examination: There was revealed a fracture of the sacrum on the left side, which ran through the sacral foramina. There was widening of both sacro-iliac joints. When the patient was lying supine, the right side of the symphysis pubis was displaced downward one centimeter in relation to the left. This asymmetry was reduced to one-half a centimeter when the weight was borne equally on the two feet. The two sides of the symphysis resumed their normal relationship when all of the weight was borne on the right foot.

Course: The pelvis was restored to its normal alignment by manipulation, with the patient under spinal anaesthesia. Alignment was maintained by traction applied to both legs for a period of two weeks; then the sacro-iliac joints were supported by a trans-sacral, tibial bone graft. The patient was relieved of pain by the manipulation and traction. He made an uncomplicated recovery from the operation and left the hospital on the twenty-fourth postoperative day. Three months after operation, a cyst developed about the left end of the graft where it entered the lateral aspect of the ilium just below the posterior-superior spine. The development of this cyst was accompanied by pain radiating through the left buttock to the posterior femoral and crural regions. This pain was relieved immediately by simple excision of the cyst which was found to lie beneath the long posterior sacro-iliac ligament. Pathological examination of the cyst showed it to be filled with clear, yellowish fluid in which floated myriad flecks of fibrin. Cultures of this fluid showed no growth. Sections of the wall of the cyst showed only cicatricial connective tissue. Two and one-half months later, a similar cyst developed at the opposite end of the graft where it emerged from the lateral aspect of the right ilium beneath the long posterior sacro-iliac ligament. The development of this cyst caused telalgia in the

right buttock, posterior femoral region, and calf. Simple excision of this cyst again relieved the pain. Cultures and pathological examination of the second cyst were of no more help in determining its origin than they were in the case of the first. One month after the removal of the second cyst, the patient was back at heavy labor. His progress has been followed for more than three years since his return to work, and there has been no further formation of cysts.

CASE 4. J. M., a white man, thirty-four years of age, came to us for relief from recurring attacks of pain in the lower back, with radiation to the right lateral femoral region, leg, and ankle. These attacks had started with an injury thirteen months before our first examination and had continued almost without cessation.

Roentgenographic Examination: An incomplete fusion of the pedicle of the left inferior articular process of the fifth lumbar vertebra, with a partial spondylolisthesis, was disclosed.

Physical Examination: A subluxation of the right sacro-iliac joint was found.

Course: This subluxation was reduced by manipulation without anaesthesia, and all radiating pain ceased immediately. The right sacro-iliac joint remained relaxed and sore, and, when a six-weeks' period of conservative treatment had failed to improve this condition, we were obliged to support the sacro-iliac joints by means of a trans-sacral, tibial bone graft. The patient was discharged from the hospital two weeks after operation and returned to heavy labor at his usual occupation in four and one-half months. Sixteen months after operation, the patient developed pain in the right sacro-iliac region, which radiated to the right posterior femoral region, the right lateral crural region, the ankle, and the great toe. This pain could be produced or aggravated by pressure upon the right end of the graft which projected slightly at its point of emergence from the ilium. A cordlike structure could be felt at this point, which, when rolled between the examiner's finger and the graft, "telegraphed" the pain down the leg to the ankle. An injection of 2 per cent. procaine at this point was accompanied by a temporary aggravation of the radiating pain. This was followed by relief from all symptoms, which lasted for more than one hour. Because of the success of this diagnostic test, we hospitalized the patient and explored the right end of the graft. No definite pathological process was found in the graft, in the periosteum, in the ligaments, or in the muscles. The long posterior sacro-iliac ligament was freed subperiosteally for one or two inches in all directions from the end of the graft, and the wound was closed. On the day after the operation, the patient was up and about the ward, completely free from symptoms. On the fourth postoperative day, the patient suddenly developed a subperiosteal hematoma in the operative wound. The tension of this hematoma caused a return of symptoms exactly like those of which the patient had complained before operation, and evacuation of the hematoma immediately relieved these symptoms. Because of continued hemorrhage, the wound was packed tightly. Tight packing caused the same telalgia, and the removal of the packing relieved it. The patient made an otherwise uneventful recovery and returned to his usual occupation in one month. There were no further recurrences in a two-year follow-up.

These two cases seem to show that *typical telalgia can be caused by a simple increase in the tension of the posterior sacro-iliac ligaments and the periosteum to which they are attached.* With the two cases recently reported by Heyman, in which "sciatic pain was relieved promptly and permanently by subperiosteal stripping of the gluteus maximus muscle and ligaments from the posterosuperior spine of the ilium", they seem to show that surgical release of this pathological tension stops the telalgia.

SUMMARY

1. The authors have attempted to present the syndrome of sacrarthrogenetic telalgia and to locate the origin and to trace the course of each of its components.

2. Five outstanding sources of confusion in the literature dealing with sciatica and low-back pain are:

   a. The inaccuracy of the nomenclature of referred pain.
   b. The influence of inaccurate nomenclature on pathological concepts.
   c. The difference of opinion in regard to the localization of dermatomic areas.
   d. The lack of specific descriptions of the innervation of the upper sacral joints and their ligaments.
   e. The vague descriptions of tenderness of various anatomical structures.

3. In presenting the results of their clinical and anatomical research, the authors have included only those findings which are related to each of the sources of confusion.

CONCLUSIONS

1. The term "sacrarthrogenetic telalgia" accurately describes the syndrome of pain which originates in the sacro-iliac and sacrolumbar articulations and their accessory ligaments. The referred pain (telalgia) affects the gluteal or the sacral region, or both regions, and may affect any part or all parts of the lower extremities and genito-inguinal regions except the internal crural and plantar regions. The lesions that produce this type of pain are associated with lateral spinal scoliosis. They do not cause objective neuropathological manifestations other than reflex physiopathic disorders and the atrophy of disuse.

2. Sacrarthrogenetic telalgia is not the result of irritation or compression of the trunks of peripheral nerves and must not be confused with radiculitis, neuritis, or neuralgia.

3. When caused by intra-articular lesions of the upper sacral joints which do not affect the extra-articular ligaments, telalgia appears only in the intergluteal triangle.

4. Pathological changes in the tension of, or irritative stimuli applied to, the extra-articular ligaments of the upper sacral joints cause telalgia in the lower extremities.

5. Telalgia that affects the lateral crural region originates in the posterior sacro-iliac and sacro-ischial ligaments.

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A METHOD OF BLIND PEGGING FRACTURES OF THE NECK OF THE FEMUR, USING A SMITH-PETERSEN NAIL OR A BONE GRAFT AS A MEANS OF INTERNAL FIXATION

BY WILBUR J. COX, M.D., SAN FRANCISCO, CALIFORNIA

The following method has proved very satisfactory in fixing recent fractures of the neck of the femur with a Smith-Petersen nail or an autogenous bone graft. The success of this method, as of many other blind methods described in the literature, depends on the accurate insertion of a test pin from the base of the trochanter to within a few millimeters of the articular surface of the head to act as a guide.

TECHNIQUE

After x-rays have been taken of both hips, with the anteroposterior roentgenogram of the normal hip taken in extreme internal rotation, the patient is placed on a Hawley table with the buttock on the injured side resting on a cassette tunnel. The uninjured lower extremity is placed in traction to fix the pelvis. The fractured hip is manipulated by the modified Leadbetter method. The author has found this method of manipulation to be most satisfactory in the reduction of such fractures. Check-up anteroposterior and lateral x-rays of the hip are then taken. The lateral

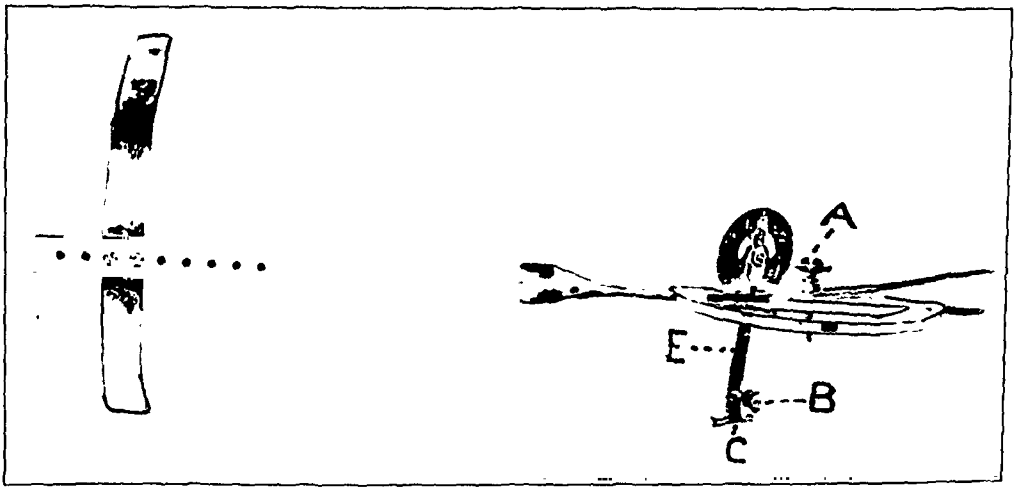

FIG. 1

Protractor assembled for left hip. By loosening the nut (*A*), the arms of the protractor may be set at the normal angle of the neck and shaft of the femur. The nut may be completely removed and the protractor may then be turned over and reassembled to fit the opposite hip. By loosening the set screw (*B*), the arm (*C*) can be raised or lowered, so that the test pin can be started midway from the anterior and posterior borders of the base of the greater trochanter. *E* indicates the lever arm.

view is taken after the method described by Leonard and George; in order to take such a view, it is necessary to remove the perineal post.

When a satisfactory reduction has been obtained, an assistant holds

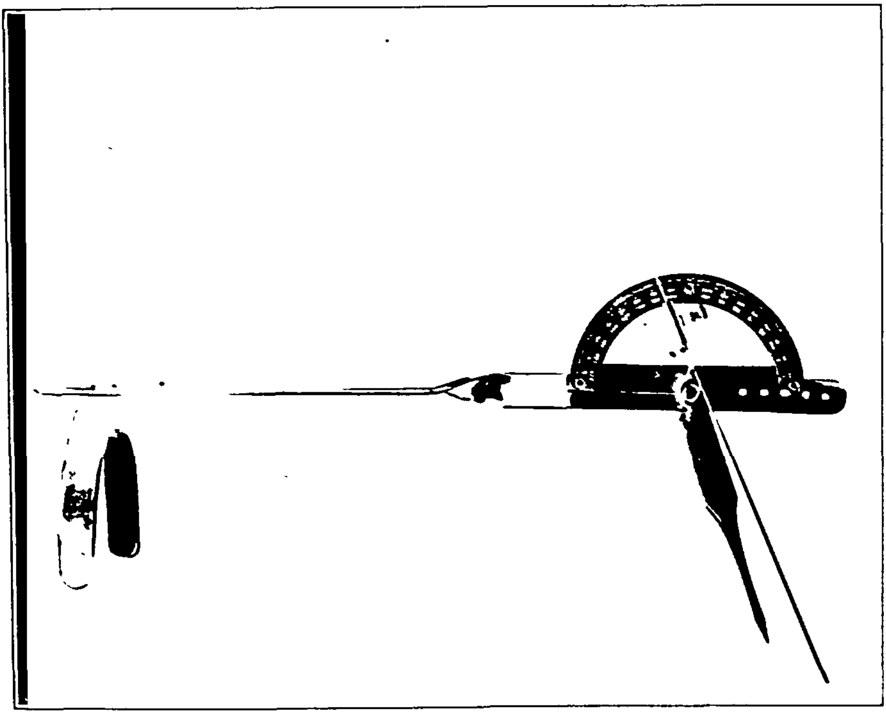

Fig. 2

Inferior view of protractor when assembled for left hip.

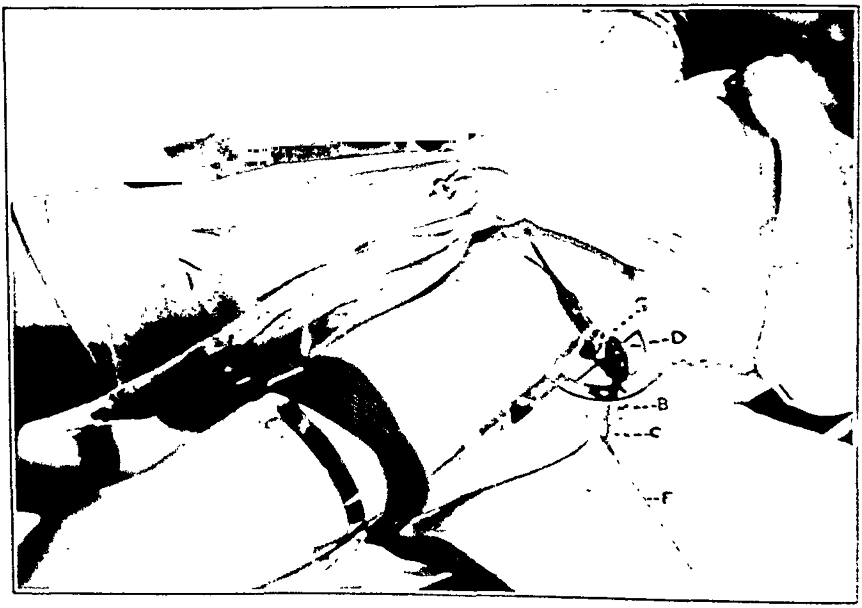

Fig. 3

Protractor placed in proper position ready for insertion of the test pin. By loosening the screw (*D*), the angle of the test pin may be changed in order to assist the operator in drilling the pin in a transverse plane. *F* indicates the Kirschner wire.

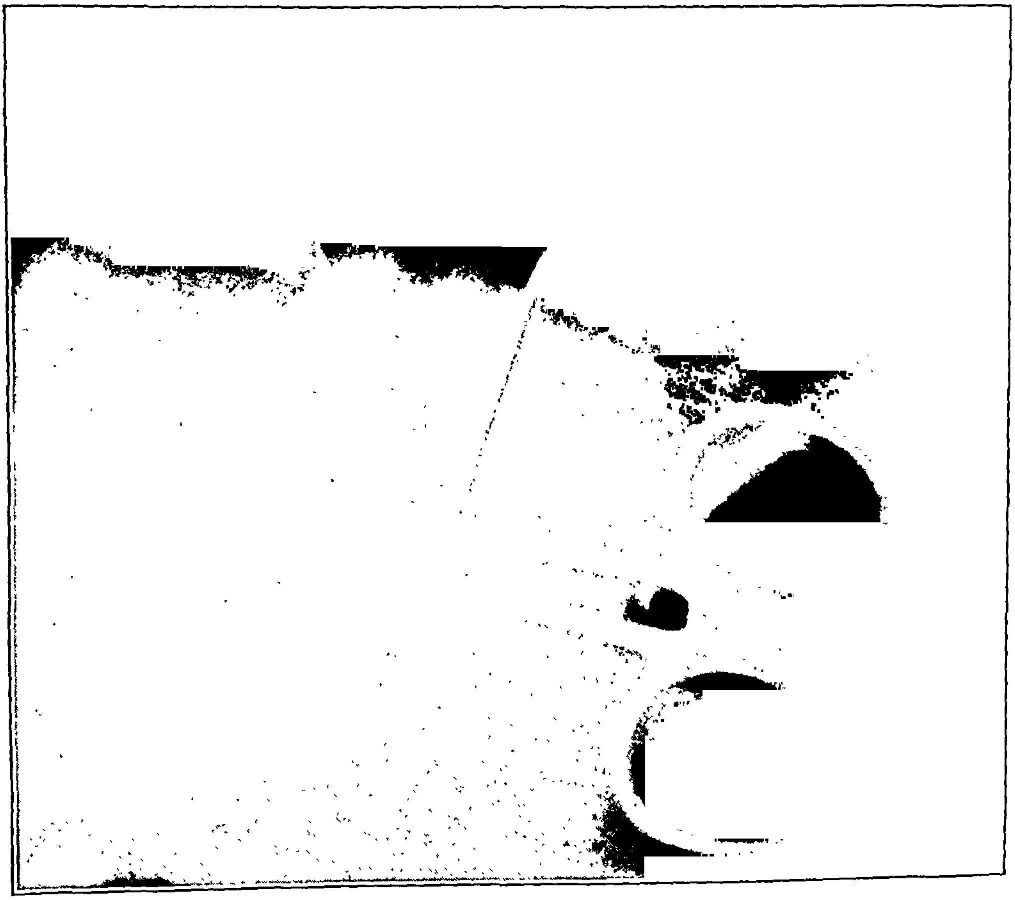

Fig. 4

Anteroposterior view of hip, showing the test pin in proper position.

Fig. 5

Lateral view of neck of the femur, showing the test pin in proper position.

the lower extremity on the injured side in abduction and marked internal rotation, and the hip joint is prepared for operation. A four-inch incision is then made, exposing the base of the trochanter. The writer uses a special protractor (Figs. 1, 2, and 3) as a means of introducing the test pin into the neck of the femur. After the normal angle of the neck and the shaft of the femur has been measured from the x-rays of the uninjured hip, taken in internal rotation, the arms of the protractor are set at the same angle. The protractor is then placed in proper position on the anterior surface of the hip with the hole which admits the test pin opposite the base of the trochanter and midway between the anteroposterior borders. The test pin is then threaded through the hole and drilled into the neck and head of the femur in a horizontal plane for a distance of nine centimeters.

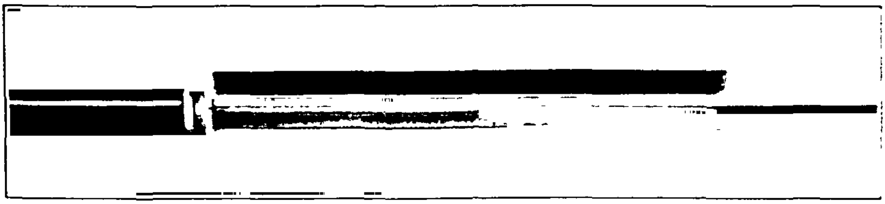

FIG. 6

Smith-Petersen nail with a hole drilled in the cap just off center and a Kirschner wire threaded through it.

One does not have to pay any attention to the angle of torsion or anteversion, as, when the lower extremity is abducted and markedly rotated internally, the neck of the femur is in a horizontal plane. The position of the test pin is then checked with anteroposterior and lateral roentgenograms of the neck of the femur. Figures 4 and 5 show the test pin in proper position.

If a bone graft is to be used as a means of internal fixation, it is imperative to drill the test pin as closely through the center of the neck as possible, but, if a Smith-Petersen nail is to be used, it makes no difference whether the test pin is on the superior or inferior side of the center of the neck, as long as the lateral view shows it to be in good position. This is one disadvantage of a hollow Smith-Petersen nail. The writer uses a Smith-Petersen nail with a hole drilled in the cap, and the end of the test pin can be threaded through the hole. In this way, the nail can be rotated about the pin and driven into the neck parallel with the pin on either the superior or the inferior side, thus compensating for the fact that the test pin is not in the center of the neck.

It is very important to use a nail of the proper length. If it is too long, it will penetrate the head; if it is too short, the fragments will not be properly fixed. The length of the nail to be used depends upon the relation of the end of the test pin to the articular surface of the head of the femur. If, when drilled into the neck for a distance of nine centimeters, the test pin just touches the articular surface of the head, an eight-centi-

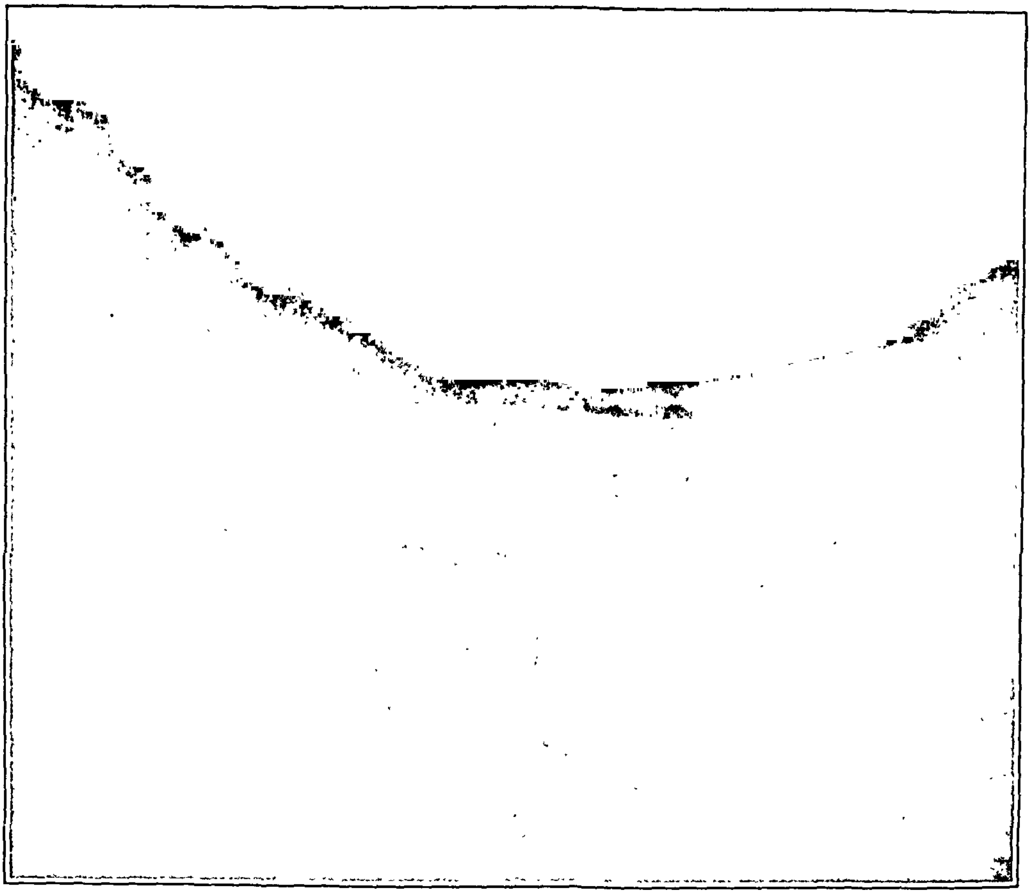

FIG. 8

FIG. 7

meter nail should be used; if the test pin does not penetrate deeply enough into the head when drilled in nine centimeters, a ten-centimeter nail should be used. That is why nine centimeters has been adopted as the distance for drilling the test pin. It has been the writer's experience that it is necessary to use a nine-centimeter nail more frequently than any other length. A nail starter should be used before the nail is driven home; otherwise the greater trochanter is liable to be fractured. Also, in driving the nail, one should strike with moderate force, following through with the force as when driving a golf ball. The writer feels that this is very important, because, if light taps are made on the nail, distraction of

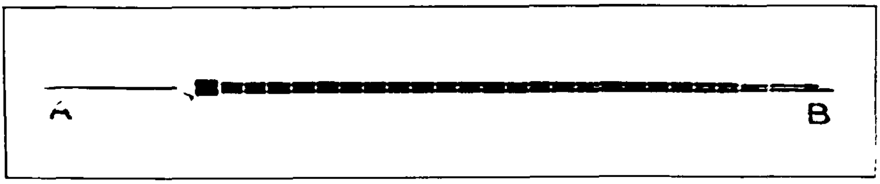

FIG. 9

Hollow drill graduated in centimeters.
A: Kirschner wire threaded into the drill; *B:* Fits into the Albee electric motor.

the fragments will result. The author has recently seen three cases in each of which there had been a perfect reduction of the fracture, followed by distraction of the fragments when the nail was driven home, because of light tapping. After the nail is driven home, the fragments are impacted and the wound is closed. Figures 7 and 8 show a fracture of the neck of the femur which has been fixed by this method.

In case a bone graft is to be used as a means of internal fixation, the graft bed is prepared by drilling a hole half an inch in diameter through the neck of the femur by threading the test pin into the hollow drill as shown in Figure 9.

Eighteen fractures of the neck of the femur have been fixed with Smith-Petersen nails by the method described, without any complication which can be attributed to the method. The youngest patient was fifty and the oldest, eighty-four.

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SOME ORTHOPAEDIC FINDINGS IN NINETY-EIGHT CASES OF HEMOPHILIA *

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From the University of Illinois, College of Medicine, Chicago

Hemophilia, a sex-linked, hereditary disease limited to the male sex, is characterized clinically by excessive hemorrhage which may occur from any part of the body. The only constant abnormal laboratory finding is a prolongation of the coagulation time of the blood. The most characteristic location of hemorrhage is into the joints; for this reason, a large number of hemophiliacs consult orthopaedic surgeons.

From the standpoint of joint treatment, there is little to be said except from a conservative point of view,—that is, injury to the joints should be avoided and those joints already involved should be put at rest. In the acute stage, the application of ice bags seems to lessen the pain, to reduce the swelling, and to shorten the duration of invalidism. If the hemorrhage is extensive, the arterial pulsation distal to the involved part should be carefully watched, for, if the arterial pressure is lowered by loss of blood and the extravascular pressure is increased by the swelling, the blood supply to the distal part may be cut off and a nutritional gangrene may develop (Fig. 1). If the pulsation in the

Fig. 1-A

Fig. 1-B

Case 4, F. H. Gangrenous foot which followed extensive hemorrhage of the leg. No surgical interference; gangrenous portion sloughed spontaneously without hemorrhage.

Fig. 1-A: Photograph taken early in March, showing extent of the gangrene.

Fig. 1-B: Photograph taken seven months later after spontaneous sloughing of gangrenous portion.

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 7, 1935.

extremity is greatly diminished or entirely cut off, blood transfusion is indicated to restore the blood volume and to raise the blood pressure.

In the chronic stage, after contracture has occurred, the treatment should be directed toward overcoming the contracture and restoring function to the joint. This treatment consists of very slow traction, careful diathermy, gentle massage, and closely observed casts and turnbuckles, followed by slow and cautious institution of motion. Such treatment frequently requires many months. The injured joints are kept at rest, first in bed, later by casts, then by the use of crutches, and still later by the aid of a cane. These corrections cannot be hurried for fear of producing another hemorrhage into the same joint, which means beginning the entire process over again.

From 1930 to 1935, ninety-eight cases * of hemophilia were studied at the Research and Educational Hospital and the Illinois Surgical Institute for Children. The findings are included in Table I.

At the time of the first examination, the ages of the patients ranged from birth to sixty-five years. Seventy-seven patients (78.5 per cent.) gave a history of joint involvement, while sixty (61.2 per cent.) had permanent joint deformity. The percentage of joint involvement is actually much higher than these figures would indicate because in the average case it is a rather late manifestation, and many of these patients are young children who undoubtedly will later develop joint hemorrhage. Of the sixty-five patients ten years of age and over, fifty-two (80 per cent.) gave a history of joint involvement. Of the joints involved, the knee was by far the most commonly affected (68 per cent.). Next in order of frequency were the ankle (56 per cent.), the elbow (53 per cent.), the hip (16 per cent.), and then, more rarely, the small joints,—the fingers (15 per cent.), the wrist (5 per cent.), and the toes (2 per cent.). The shoulder seemed to have escaped permanent deformity more than any other joint. The spine was involved in three cases.

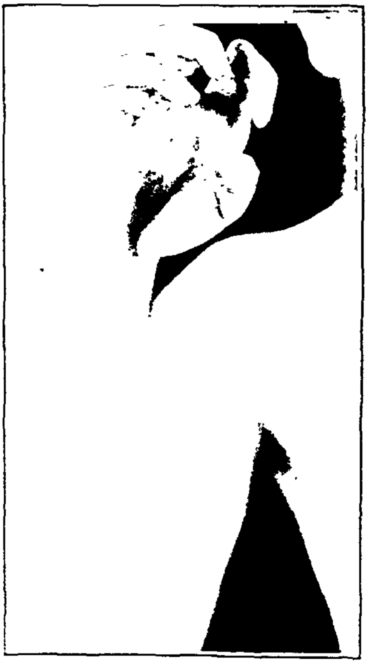


FIG. 2

Case 7, M. Z. Volkmann's contracture following extensive hemorrhage which included the entire arm.

The patient in Case 1 suffered his first joint hemorrhage at the age of three months, while the patient in Case 2 developed his earliest intracapsular hemorrhage at twenty-three years of age. These two patients were the youngest and the oldest in the group to develop hemarthrosis.

* The clinical and genetic aspects of this same group of cases have been covered in a monograph by Dr. Carroll L. Birch of the University of Illinois, College of Medicine.

TABLE I

SUMMARY OF JOINT INVOLVEMENT IN NINETY-EIGHT CASES OF HEMOPHILIA

Case	Age at First Examination	First Hemorrhage	Joints First Involved	Subsequent Joints Involved	Permanent Joint Deformity
1. L. S.	8 years	Elbow, at 3 months	Elbow, at 3 months	Practically all joints	Knees, elbows
2. J. M.	52 years	Bit tongue, at 5 years	Knee, at 23 years	Knees, elbows, ankles, fingers	Knees, elbows
3. L. B.	22 years	Bruises, at 6 months	Ankle, at 3 years	Practically all	Knees, elbows
4. F. H.	9 months	Hematoma, at birth	None	None	None
5. L. H.	30 years	Tooth, at 1 year	No recollection	Practically all	Practically all joints, complicated by arthritis deformans
6. H. P.	11 years	Circumcision, at 12 months	Right knee, at 4 years	Knees, spine	Spine
7. M. Z.	21 years	Circumcision, at 8 days	Hip, at 6 years	Practically all	Hips, elbows, knees, ankles, wrist, hand
8. C. L.	26 years	Subcutaneous, at 8 months	Knee, at 5 years	Practically all	Hips, knees, elbows, wrists
9. W. K.	15 years	Bruises, at 6 months	Right knee, at 5 years	Practically all	Elbows, knees, left hip
10. E. B.	19 years	Swelling of hand, at 6 months	Hips, at 4 years	Knees, ankles, elbows	Knees, elbows, ankles
11. R. R.	49 years	Knee, at 3 years	Knee, at 3 years	Knees, ankles, elbows	Knees, ankles, elbows
12. L. C.	31 years	Teeth, at 6 years	Knee, at 6 years	Ankles, knees, elbows	Ankles, knees, elbows
13. M. B.	47 years	Bit tongue, at 5 years	Knee, at 6 years	Practically all	Right knee, right hand, elbows
14. W. R.	34 years	Cut head, at 8 months	Ankles, at 3 years	Hips, ankles, knees, elbows	Knees, elbows
15. E. C. L.	12 years	Hematoma, at 3 months	Knee, at 3 years	Elbows, knees, ankles	Knees, elbows
16. W. P.	32 years	Hematoma, at 1½ years	Wrist, at 6 months	Practically all	Knees, elbows
17. F. R.	10 years	Cutting of teeth, at 10 months	Ankle, at 1½ years	Knees, ankles, elbows	Knees, elbows
18. R. R.	18 years	Umbilicus, at birth	Ankle, at 18 months	Knees, ankles, elbows	Knees, elbows

TABLE I—*Continued*

Case	Age at First Examination	First Hemorrhage	Joints First Involved	Subsequent Joints Involved	Permanent Joint Deformity
19. J. R.	34 years	Knee, at 6 years	Knee, at 6 years	Practically all	Knees, elbows
20. H. Z.	16 years	Circumcision, at 8 days	Ankle, at 7 years	Practically all	Knees, elbows
21. J. W.	37 years	Subcutaneous, at 5 days	Knee, at 6 years	Practically all	Knees, elbows
22. L. H.	11 years	Hand, at 4 months	Elbow, at 3 years	Wrist, ankles, elbows, knees	Knees, elbows
23. E. K. L.	30 years	Ankle, at 3 years	Ankle, at 3 years	Practically all	Knees, elbows
24. H. H.	10 years	No recollection	Ankle, at 4 years	Ankles, elbows, knees, shoulders	Knees, elbows
25. M. H.	12 years	Bruises, at 8 months	Knee, at 3 years	Ankles, elbows, knees, shoulders	Knees, elbows
26. R. M.	18 years	No recollection	Elbows, at 18 months	Ankles, knees, elbows, wrists, fingers	Knees, elbows
27. W. G.	20 years	No recollection	Elbows, at 18 months	Knees, elbows	Knees, elbows
28. J. A.	7 years	Foreskin stretched, immediately after birth	Wrist, at 2 years	Knee, wrist, elbows	Knee, elbows
29. J. O.	18 years	Skin, at 5 months	Elbow, at 4 years	Practically all	Knee, elbow
30. R. T.	14 years	Circumcision, at 8 days	Elbow, at 11 years	Elbows, knees, ankles, wrists	Knee, elbow
31. J. K.	17 years	Circumcision, at 6 weeks	Knee, at 6 years	Practically all	Knee, hips
32. R. W.	17 years	Circumcision, at 8 days	Knee, at 6 years	Knees, elbows, hips, shoulder	Knee, hip
33. J. W.	22 years	Circumcision, at 8 days	Knee, at 4 years	Practically all	Knee, shoulder
34. W. U.	10 years	Circumcision, at 9 days	Elbow, at 5 years	Elbows, knees, hips, shoulders	Knees
35. J. H.	13 years	Circumcision, at 9 days	Knee, at 4 years	Knees, elbows	Knees
36. J. J.	30 years	Knee, at 10 years	Knee, at 10 years	Practically all	Knees
37. R. J. M.	35 years	No recollection	No recollection	Knees, ankles, elbows, hips	Knees
38. S. S.	28 years	Circumcision, at 8 days	Knee, at 10 years	Knees, ankles, elbows	Knees

TABLE I—*Continued*

Case	Age at First Examination	First Hemorrhage	Joints First Involved	Subsequent Joints Involved	Permanent Joint Deformity
39. D. F.	13 years	Circumcision, at 4 weeks	Hip, at 5 years	Knees, hips, wrists, ankles, fingers	Knees
40. J. S.	22 months	Circumcision, at 12 days	Knee, at 14 months	Knees	Left knee
41. L. B.	2½ years	Hematoma, at 9 months	Knee, at 18 months	Knees	Knee
42. S. C.	13 years	Cut finger, at 6 months	Knee, at 1 year	Knees, elbows, ankles	Knee
43. H. Z.	6 years	Finger, at 13 months	Knee, at 18 months	Knees	Knee
44. R. S.	8 years	Tongue cut, at 7 months	Hip, at 5 years	Shoulders, knees, ankles	Knee
45. F. O.	7 years	Tooth, at 10 months	Knee, at 6 years	Knee	Knee
46. H. W.	15 years	No recollection	No recollection	Knee	Knee
47. S. M.	22 years	No recollection	Knee, at 14 months	Knees, elbows, fingers, hips	Elbows, hips, ankles
48. B. E.	14 years	Cutting of tooth, at 6 months	Ankle, at 4 years	Ankles, knees, elbows, right hip	Elbows, ankle
49. J. P.	16 years	No recollection	Elbow, at 7 years	Elbows, knees, ankles	Elbows, ankles
50. E. C.	11 years	Bit tongue, at 13 months	Spinal column, at 2 years	Ankles, knees, shoulders, hips, spine, elbows	Elbows
51. J. S.	8 years	Circumcision, at 8 days	Elbow, at 3 years	Elbows, ankles, knees	Elbows
52. L. B.	11 years	Bruises, at 6 months	Elbow, at 5 years	Elbows, ankles, knees	Elbows
53. G. L.	30 years	Hematoma, at 6 months	Elbow, at 5 years	Elbows, hips, knees, fingers, toes	Elbows
54. D. M.	6 years	Cut lip, at 3 years	Elbow, at 5 years	Elbows	Elbow
55. B. C.	14 years	Cut finger, at 6 months	Elbow, at 9 years	Knees, ankles, wrists	Left elbow
56. J. F.	6 years	Cut lip, at 1 year	Ankle, at 3 years	Ankles, elbows	Left elbow
57. M. B.	65 years	Teeth, at 6 years	Elbow, at about 40 years	Elbow	Left elbow
58. S. R.	12 years	Subcutaneous, at 4 months	Ankles, at 2 years	Ankles, knees, elbows, shoulders, toes, fingers	Elbows, knees

TABLE I—*Continued*

Case	Age at First Examination	First Hemorrhage	Joints First Involved	Subsequent Joints Involved	Permanent Joint Deformity
59. J. G.	12 years	Knee, at 6 years	Knees, at 6 years	Shoulders, knees, ankles	Knee
60. C. F.	58 years	No recollection	No recollection	Knees	Knees
61. A. G.	11 years	Cut finger, at 5 years	Ankle, at 6 years	Ankles, knees, elbow	Knee
62. B. S.	8 years	Hematoma, at 1 year	Knee, at 2 years	Elbow, knee, ankles, hip	None
63. D. S.	9 years	Hematoma, at 6 months	Knee, at 2 years	Knees, ankles, elbows	None
64. R. C.	4 years	Umbilicus, at birth	Ankle, at 18 months	Ankles, knees	None
65. R. B.	4 years	Bit lip, at 10 months	Shoulder, at 3 years	Ankle, knee	None
66. J. O.	27 months	Circumcision, at 10 days	Ankle, at 2 years	Ankle, knee	None
67. D. V.	6 years	Ankle, at 1 year	Ankle, at 1 year	Elbows, knees, ankles	None
68. H. P.	2 years	Circumcision, at 8 days	Right knee, at 15 months	Knees	None
69. A. M.	7 years	Attempted circumcision, at 8 days	Knee, at 1 year	Knees, elbows	None
70. T. S.	4 years	Hematoma, at 3 months	Spine, at 4 years	Spine	None
71. G. W.	4 years	Cut lip, at 1½ years	Left ankle, at 4 years	Left ankle	None
72. L. B.	7 years	Nosebleed, at 9 months	Left elbow, at 5 years	Ankles, elbows	None
73. D. G.	30 years	Hematoma, at 3 months	Ankle, at 6 years	Knee, ankle	None
74. S. S.	5 years	Circumcision, at 8 days	Knee, at 3 years	Knees	None
75. T. W.	12 years	Throat, at 11 months	Ankle, at 9 years	Ankles, hips	None
76. V. L.	4½ years	Circumcision, at 5 days	Right knee, at 4½ years	Right knee	None
77. R. K.	3 years	Ankles, at 3 years	Ankles, at 3 years	Ankle	None
78. P. W.	2½ years	Circumcision, at 9 days	Ankle, at 1 year	Ankle	None

TABLE I—*Continued*

Case	Age at First Examination	First Hemorrhage	Joints First Involved	Subsequent Joints Involved	Permanent Joint Deformity
79. R. R.	7 months	Circumcision, at 8 days	None	None	None
80. R. Z.	1 year	Bruises, at 3 months	None	None	None
81. T. S.	40 years	Cut lip, at 18 months	None	None	None
82. W. G.	37 years	Teeth, at 1 year	None	None	None
83. J. M.	11 years	Baby teeth	None	None	None
84. D. C.	24 years	Teeth, at 1 year	None	None	None
85. P. D.	8 years	Nosebleed, at 2 years	None	None	None
86. M. F.	16 years	Nosebleed, at 3 years	None	None	None
87. E. K.	6 years	Teeth, at 6 months	None	None	None
88. D. K.	Birth	Umbilical cord, at 4 days	None	None	None
89. C. L.	22 years	Adenoids removed, at 4 years	None	None	None
90. E. P.	12 years	No recollection	None	None	None
91. T. S.	14 years	Nasal, at 2 years	None	None	None
92. J. S.	11 years	No recollection	None	None	None
93. P. S.	12 years	No recollection	None	None	None
94. K. T.	8 years	Nosebleed, at 2 years	None	None	None
95. K. T.	8 years	Nosebleed, at 2 years	None	None	None
96. W. Z.	17 years	Nosebleed, at 2½ years	None	None	None
97. Q. R.	11 years	Nasal, at 2 years	None	None	None
98. H. F.	18 years	Circumcision, at 9 days	None	None	None

Case 3 is of special interest to the author because in 1930 he performed an ovarian transplantation on this boy. There was no excessive bleeding at the time of operation and the patient remained symptom-free for five and one-half months. Following this, he also suffered two fractures of the femur, both of which healed surprisingly well, so that a satisfactory leg resulted. It is of interest that this patient's maternal grandfather bled to death following a fracture of the leg.

From birth, the patient in Case 4 bruised easily. At nine months of age the diagnosis of hemophilia was made by blood examination. He is a member of a high-grade hemophilic family. His maternal uncle is also included in the group of cases reviewed in Table I. Three other maternal uncles have bled to death. In February 1934, the patient suffered a small two-inch burn on the external aspect of the leg between the knee and ankle. This was followed by extensive hemorrhage which included the whole extremity. He became very anaemic and ran a high temperature. Three weeks later, when the swelling and discoloration began to subside, it was found that the foot was gangrenous (Fig. 1-A). At this time, the patient received two blood transfusions. It was in this condition that he was brought to the hospital. Pneumonia developed and three blood transfusions were given. Nothing was done to the foot and no bandages were applied. The affected area was left exposed and was merely protected from external injury. When the gangrenous portion became loosened, it was strapped on with adhesive tape. After seven months, there was a spontaneous sloughing of the entire portion of the foot without the loss of a single drop of blood (Fig. 1-B). This is the only case of hemophilia with gangrene which the author has observed.

The patient in Case 5 has a combination of generalized proliferative arthritis and hemophilic hemarthrosis. Practically all of the joints are involved and many are permanently deformed. He has been confined to a wheel chair for six years.

In Case 6 there is a definite destruction of the spine which undoubtedly followed a hemorrhage in this location. The case was first diagnosed as Pott's disease and the patient was kept on a frame for two years.

The patient in Case 7 has a Volkmann's contracture following extensive hemorrhage which involved the entire arm (Fig. 2).

The patient in Case 34 has suffered so many hemorrhages into his knee that he has been able to walk but nine months during the last five years. The patients in Cases 94 and 95 are twins.

CONCLUSIONS

General or constitutional treatment of hemophilia presents a chaos of conflicting opinions, out of which the internist may perhaps bring order. The present study, showing the high percentage of joint involvement, demonstrates that the orthopaedic surgeon has an interest in the patient with hemophilia and may have an important rôle to play in the early management of these cases and in the surgical rehabilitation of deformed joints, if and when a means for the control of hemorrhage is found.

CONGENITAL ANOMALY OF THE CORACOID

Os Coracosternale Vestigiale

BY JEROME G. FINDER, M.D., IOWA CITY, IOWA

From the Department of Orthopaedic Surgery, Children's Hospital, Iowa City
Service of Arthur Steindler, M.D.

Congenital anomalies of the coracoid portion of the human scapula are very rare. The following case of a vestigial coracosternal bony process represents an unusual anomaly in man. As far as can be determined, this particular anomaly has never been reported before. In this instance, it was associated with other congenital defects,—namely, spina bifida of the cervical region, Sprengel's deformity, and torticollis.

CASE REPORT

The patient was first seen on February 13, 1934, when seven months old. He had been delivered of an eclamptic, primiparous mother by Caesarean section. Shortly after, a prominence of the right clavicle (?) had been noted, associated with some twisting of the head toward the left side. The torticollis increased and the patient did not use the right arm very actively.

Physical Examination (September 19, 1934)

Only the factors relevant to the congenital defects are recorded here.

Fig. 1

Front view of patient, aged nineteen months, showing the facial asymmetry, torticollis, and elevation of the right shoulder.

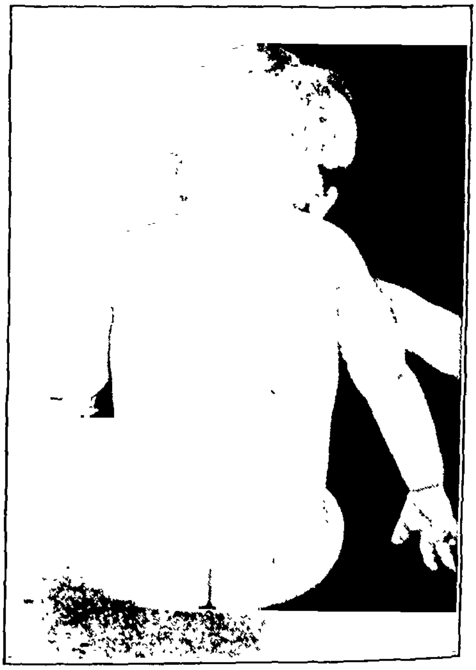


Fig. 2

Posterior view of patient, revealing the rotation of the head, the low hair line, the elevation of the right shoulder, and the winged, elevated right scapula.

Head and Neck: The anterior fontanel had a small patency; the posterior suture was closed. A moderately advanced torticollis existed,—occiput right and face directed to the left. Facial distortion was also evident, with the convexity to the left (Fig. 1). The hair line posteriorly was short and low, simulating that of the Klippel-Feil syndrome (Fig. 2).

Despite the torticollis, there was no particular tension of the right sternocleidomastoid muscle, but there was a definite band of tense structures in the direction of the levator scapulae muscle and the upper fibers of the trapezius muscle. Movements of the head and neck were fairly free except for rotation and lateral flexion to the right.

Shoulder Girdle: The right shoulder was definitely elevated (Figs. 1 and 2) and associated with a high scapula which "winged out" moderately. Voluntary movements of the right arm were free in all directions, although the patient was disinclined to use the extremity. At the junction of the middle and outer thirds of the clavicle, a sharp bony projection protruded upward and medially. This projection was easily palpable under the skin and was visible when the child's head was rotated to the left (Fig. 3).

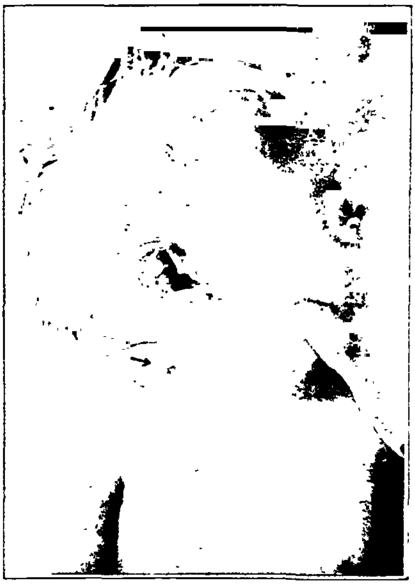


FIG. 3

The head is turned to the left to bring out the bony prominence (indicated by the arrow) caused by the coracosternal bone of the right side.

Roentgenographic Examination

The neural arches of the third to seventh cervical vertebrae inclusive showed incomplete closure (Fig. 4). The entire right scapula was elevated and showed hypertrophy of the upper border. The acromion, coracoid, and the distal end of the clavicle were malformed. An elongated, tapering bony structure arose from the base of the coracoid, medial to the glenoid fossa. It was directed upward and medially, being definitely separated from the cervical spine by a distance of at least one inch (stereoscopic reading). This structure was also separate and distinct from the spine of the scapula, the direction of which was about 45 degrees closer to the horizontal.

Diagnosis

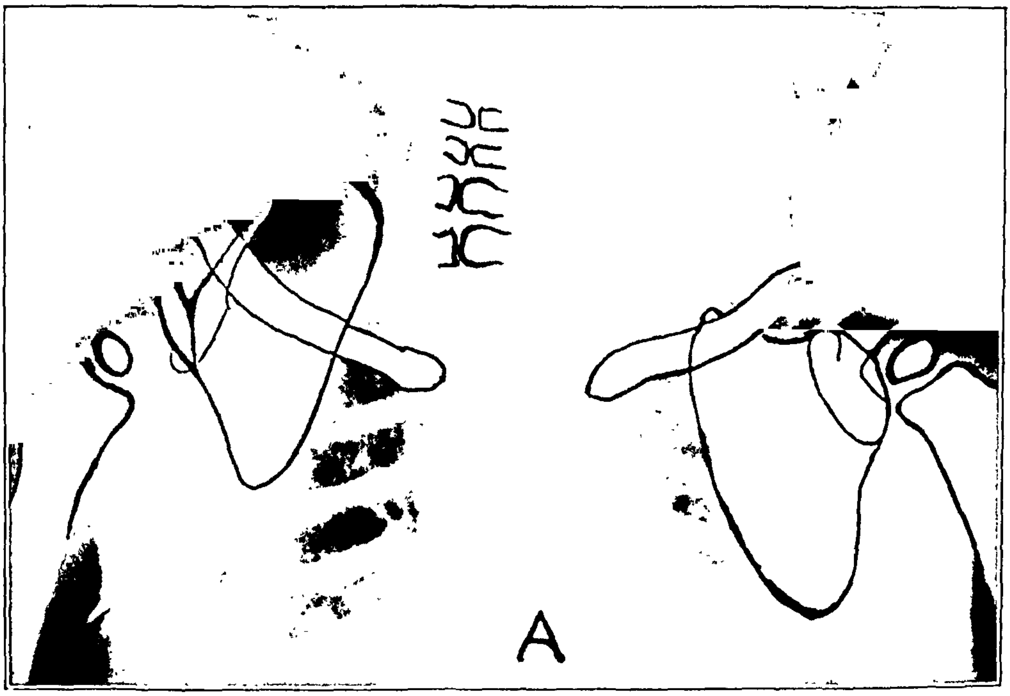
1. Spina bifida occulta cervicalis.
2. Scapula alata dextra (Sprengel's deformity).
3. Torticollis.
4. Os coracosternale vestigiale.

DEVELOPMENTAL ANATOMY

According to Broom, in 1897, marsupials showed a phylogenetic connection between the coracoid and the sternum. Ontogenetically, he found this relationship in early stages; in older embryos, however, the medial portion of the coracoid degenerated and lost its connection with the sternum.

Gegenbauer, Parker, and Butschli found that in certain of the gnawing animals there was a small bone contiguous to the first rib and the

sternum, and these authors considered this bone to be an arrest of the medial portion of the coracoid. On the other hand, certain authors, such as Nauck and Vialleton, claimed that higher mammals had no coracoid at all, but that it was a new formation phylogenetically. This statement, however, probably is incorrect, because Subkowitsch demonstrated the existence of a coracoid in young human embryos as well as in bats.



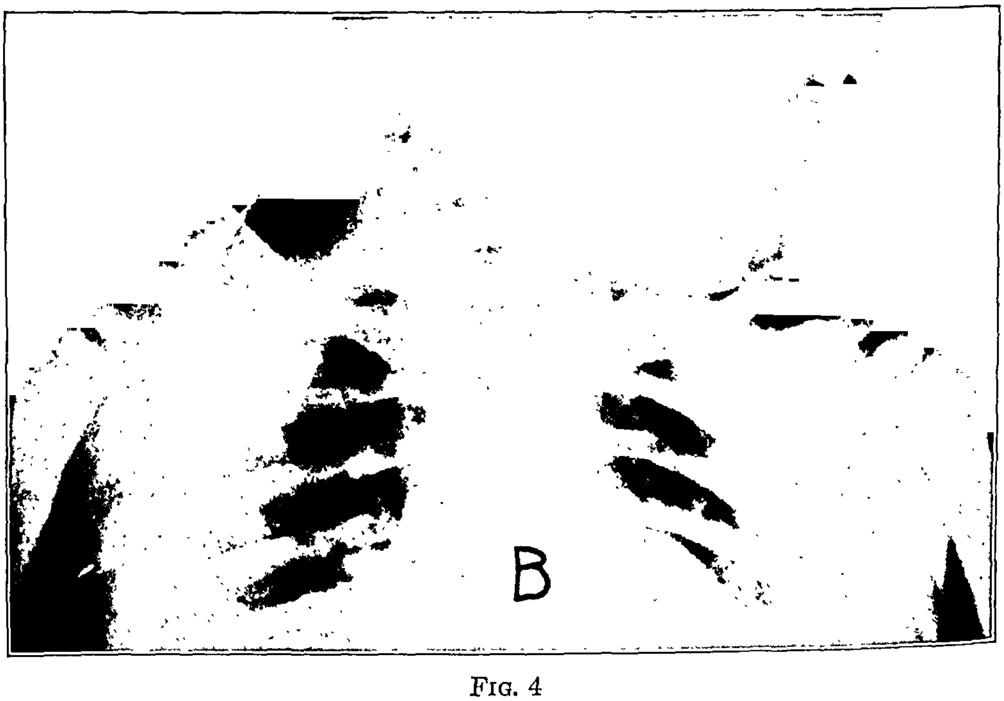


FIG. 4

The main defects have been accentuated in *A* by black outlines; the normal left scapula is also touched up for comparison. The unaltered x-ray, *B*, represents the same view as *A*, taken when the patient was fourteen months old.

Subkowitsch stated that the embryos studied showed a definite connection between the coracoid and the sternum. The coracoid always developed from a base in connection with the glenoid. At the same time, a mass of mesenchymatous cells appeared and spread as a bar toward the mesenchymatous anlage of the sternum, with which it subsequently united. Somewhat later, the mesenchymatous bar divided in its long axis into an upper (cephalad) and lower (caudad) portion. These relations are nicely demonstrated in a model reconstructed from serial sagittal sections of the human embryo (Fig. 5). Still later, the cephalad layer began to disappear from its coracoid end, while the *caudad layer faded from its sternal end.* It is believed that all that remains of the mesenchymatous bar in the mature foetus is the coracoclavicular ligament, composed of a conoid and a trapezoid portion.

FIG. 5

The reconstructed model (after Subkowitsch), made from sagittal sections of an early human embryo, shows the lateral view of the right shoulder girdle and chest wall. The structures indicated are: coracoid process (*1*); sternum (*2*); cephalad portion of the mesenchymatous coracosternal bar (*3*); caudad layer of the bar (*4*), the lateral part of which represents the anlage of the anomaly described in this report: acromion (*5*); humeral head lying in the glenoid cavity (*6*); body of the scapula (*7*). (Reproduced from *Morphologisches Jahrbuch*, LXV, 1931, by courtesy of *Akademische Verlagsgesellschaft*.)

Since the coracosternal connection is a mesenchymatous one, the persistence of a muscle-tissue derivative in postnatal life must be considered also. Lane described an anomalous coracoclaviculosternal muscle in a powerfully built adult male. This muscle, which lay beneath the costocoracoid membrane, took origin from the whole anterior margin of the coracoid process, from a comparatively strong coracoclavicular ligament, and, to a slight extent, from the inner margin of the coracoid facet on the under surface of the clavicle. The greater part of this coracosternal muscle was fleshy and formed a muscle belly as large as that of the average normal subclavius muscle. Medially, it formed a flat tendon, about a half an inch long and an eighth of an inch wide, which inserted into the lower part of the anterior margin of the clavicular facet of the sternum. The subclavius muscle and the costocoracoid membrane were present in their otherwise normal relations.

DISCUSSION

The existence in the embryo of a mesenchymatous connection between the coracoid and sternum theoretically may furnish the basis for the persistence of a mesodermal derivative in postnatal life. It is possible for muscle, ligament, cartilage, or bone to form directly from this germ layer. The coracoclaviculosternal muscle described by Lane apparently justifies this conjecture. On the other hand, preformed tissue may degenerate and undergo fibrosis; the coracoclavicular ligament may represent such a process. As a further step, calcification and even bone formation may occur.

The associated congenital anomalies in the case reported represent developmental defects, due to the persistence of an early embryonal stage. It is, therefore, consistent to consider the persistence of the coracosternal bone in the same category as other primitive states,—namely, failure of descent of the scapula (so called congenital elevation or Sprengel's deformity) and failure of closure of the neural arches. The author believes that the anomalous bony structure in the patient whose case is reported represents the persistence of the lateral portion of the caudad layer of the mesenchymatous coracosternal bar, of which the germ cells not only failed to disappear entirely, but actually developed into a bone found normally only in mature lower animal forms. The writer would like to suggest the name *os coracosternale vestigiale* for this structure when it occurs in man.

The unilateral occurrence of all the defects indicates that some developmental derangement must have occurred in the embryo involving the upper segments of the right side. The arrest most likely occurred during the third month of intra-uterine life. This is corroborated to some extent by the scapular position, which corresponds to the level of descent in the third month of foetal life.

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UNUSUAL FRACTURES OF THE SPINE *

BY MERRILL COLEMAN MENSOR, M.D., F.A.C.S., AND
LEON O. PARKER, M.D., SAN FRANCISCO, CALIFORNIA

The following cases of fracture of the spinal column are presented to exemplify the well known fact that, although treatment of a given condition may be well standardized, problems are always arising to which no rule of thumb can be applied. The bizarre findings and excellent end results seem to justify the making of a permanent record in these cases.

CASE 1. G. C. N., aged fifty-one, a truckdriver, sustained an injury to the lower back, with consequent paralysis of the lower extremities, as the result of an accident on April 10, 1934, in which he had been dragged by a truck and jammed into a fence. He was transported to the Vallejo General Hospital where he was placed in a fracture bed with his feet strapped to the mattress. Although conscious for the first twenty-four hours following the accident, he rapidly became increasingly stuporous and finally comatose. He was seen by the authors on the fourth day following the injury, at which time he was unable to take nourishment. He was suffering from incontinence of the bladder and rectum; his breath was strong of acetone: and, although he was in an irrational state, there were constant spastic movements of the facial muscles and the upper extremities. His blood pressure was 110/55; pulse, 110; respiration, 26.

Physical examination revealed complete paralysis of the lower extremities and slight incoordinated twitching in the adductor and abductor groups of the thighs and extensors of the knees. There was loss of reflexes in the lower extremities, and the cremasteric and abdominal reflexes were absent.

Roentgenographic examination disclosed a comminuted, compressed fracture of the body and lamina of the first lumbar vertebra, with marked lateral displacement to the left of the entire spinal column. The lower portion of the twelfth dorsal vertebra on the left side had likewise been compressed.

One week following the accident, the patient was in sufficiently good condition to be transported on a Bradford frame to San Francisco by ambulance. Five days prior to his transfer, head and leg traction had been applied, but, at the end of this time, examination failed to reveal any change either in the deformity or in the return of motion to the extremities. Sensory examination, however, revealed an irregular zone of hyperaesthesia bilaterally at the level of the twelfth thoracic segment. There were isolated areas on the right foot along the medial side near the ankle where sensation to touch was present. Pain was absent in the left leg, but present on the medial side of the right leg and foot. Deep muscle sensibility, with regard to the position of the toes, was present in both feet. Pressure on the medial side of the thighs was directly recognized. Sphincter tone was present by digital examination. A two-piece plaster jacket was applied, which was left open at the site of the fracture and made continuous by lateral boards incorporated in the two halves to give a mobile apparatus, providing for possible correction at the time of operation for the lateral displacement at the site of the fracture.

On April 19, 1934, nine days following the injury, the operation was performed through the fenestrated plaster, with the patient under avertin anaesthesia. The fracture site was exposed by the usual midline incision and subperiosteal dissection. On removal of the laminae over the involved area, the spinal cord was found to be compressed and the dura torn by a large fragment of bone. This fragment was carefully removed and sufficient bone was taken from the canal to compensate for the sharp, lateral angulation

* Presented before the San Francisco Chapter of the Western Orthopaedic Association, February 26, 1935.

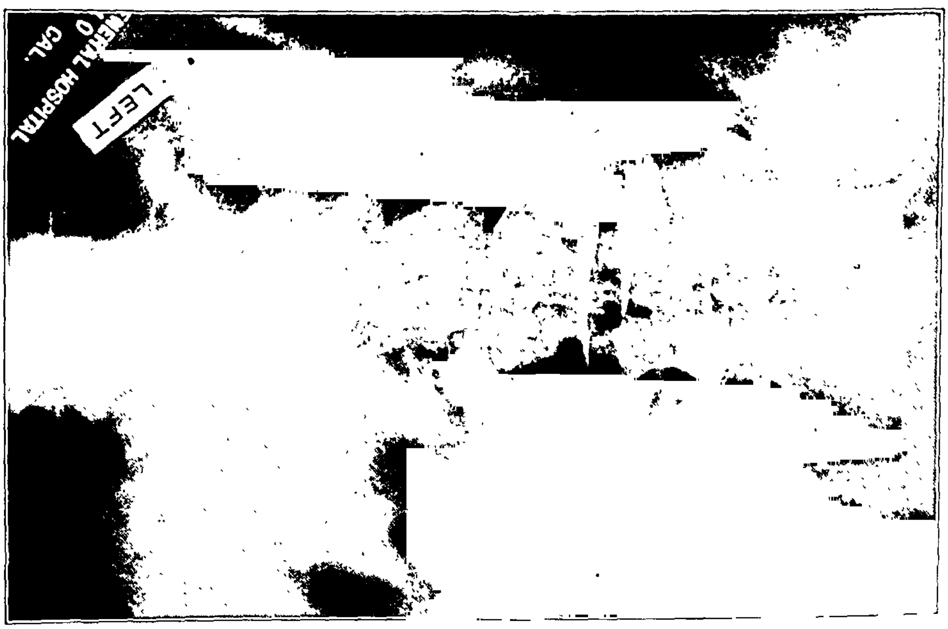

FIG. 1

Case 1, G. C. N. Showing extensive fracture of the lumbar spine, with marked lateral displacement.

FIG. 2

Case 1, G. C. N. Lateral view, showing compression of the vertebral body.

FIG. 3

Case 1, G. C. N. Showing operative correction of deformity and bone grafts *in situ*.

of the cord, caused by the displacement of the vertebral body. It is interesting to note that even at this time there was considerable reaction, resulting in a deposit of fibrinous tissue which was adherent to the dura and caused sufficient contracture to compress the cord partially. This tissue was likewise removed. With the cord free, the wooden supports in the plaster were cut and the lateral displacement was easily corrected. Some difficulty, however, was experienced in maintaining alignment.

Further exploration of the cord by incision of the dura revealed *no evidence of block or* hemorrhage. Two tibial bone grafts were placed, one on each side, along the denuded laminae and pedicles, and the wound was closed in the routine manner.

The patient's immediate convalescence was relatively uneventful and x-rays, taken April 26, 1934, revealed the spinal column to be extended and the lateral offset between the twelfth dorsal and first lumbar vertebrae to be partially corrected. The bone grafts were *in situ*, extending from the tenth dorsal vertebra to the third lumbar vertebra.

On the tenth day after operation, the original plaster was removed and the patient was fitted with a non-padded jacket, extending from the axillae down both legs to the knees. This plaster was removed on June 13, 1934, and the patient was fitted with a Taylor spinal brace.

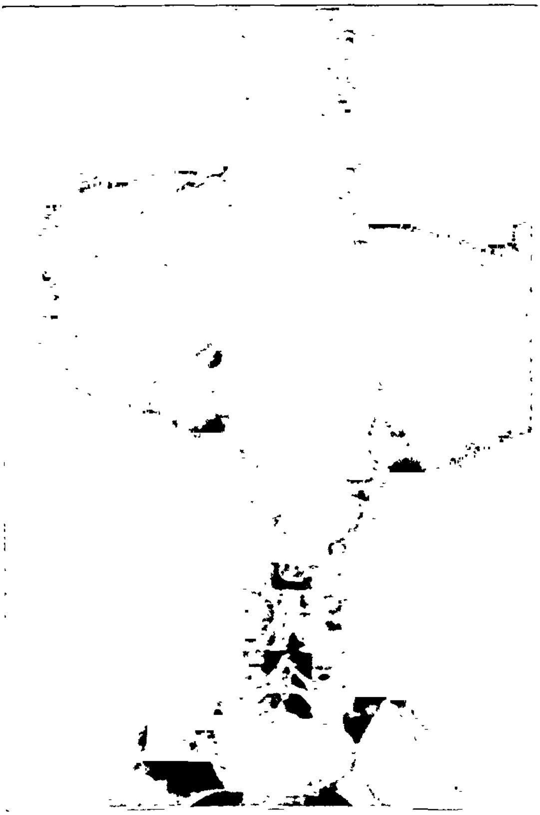

FIG. 4

Case 1, G. C. N. Showing fusion of grafts and maintenance of correction of deformity.

Certain features of the patient's convalescence are worthy of note. On May 2, 1934, approximately two weeks after the operation, it was noticed that there was a definite return of power to the hamstring and gastrocnemius groups, as well as the short flexors of the toes. There was slight return of power to both quadriceps groups. About this time and for the ensuing two weeks, the patient complained steadily of sharp, radiating pain over the dorsum of the feet and down the legs. This pain was accompanied by a slow, but definite increase in motor function. On May 19, 1934, a month after the operation, good power was noted in all muscle groups except the tibialis anticus and the extensor digitorum muscles in which only slight recovery was evident.

A month after the plaster had been removed and the patient had been fitted with a brace, he was allowed freedom in the bed, but no attempt was made to start him walking. During this time, physiotherapy and reeducational exercises were directed at the lower extremities. Movement in the knee joint was recovered rather quickly, but considerable difficulty was experienced in obtaining motion in the hip joints. This limitation of motion in the hip joints was a definite handicap when the patient began walking and continued to be a source of annoyance even when he was able to walk without crutches, as the limitation of flexion prevented him from sitting down or rising from a chair easily.

On August 16, 1934, four months after the operation, the patient was walking daily with mechanical aid, and a month later he was handling himself readily with crutches. He improved rapidly from that date and, by the seventh month, was discharged to a convalescent home, wearing a Taylor brace and a pair of foot-drop braces. Good function had returned to the muscles, with the exception of the dorsiflexors of the toes and the tibialis anticus muscle groups.

Ten months following the injury, examination disclosed the fusion of the graft to be complete. The patient was able to bend forward within seven and one-half inches of the floor, although the motions of the spine were somewhat limited, due to the fusion of the lumbar area. His general condition was such that he was discharged as cured on February 20, 1935.

At present, the patient is ambulatory, without a foot or back brace, is able to do light work, and has no complaints other than an occasional feeling of fatigue after excessive weight-bearing. His permanent disability consists solely of limited motion over the site of the spinal grafts.

CASE 2. A. D., aged fifty-nine, an electrical inspector, on September 24, 1934, fell off a fire escape from a height of three stories and landed in the cement courtyard below. The patient's back struck a clothesline pole, which broke the speed of his descent and undoubtedly contributed to the bizarre type of fracture which he sustained.

Although in a state of considerable shock when first seen by the authors within an hour after the accident, the patient was fully conscious and complained of severe pain in the lower back. Careful neurological examination failed to reveal any evidence of motor paralysis or paresis. There was moderate distension of the abdomen with urinary retention, absence of the right patellar reflex, and presence of both ankle jerks. Plantar stimulation of the feet gave plantar flexion of both great toes. Sensation to cotton and pin was preserved in both lower extremities. No sensory level could be determined on the abdomen. Slight hyperaesthesia was present over the right perineum. Sphincter tone was good. The feet were cool and moist. Pulsations were good and equal in the peripheral arteries.

An interesting phenomenon was observed,—namely, when an attempt was made to elicit the right patellar reflex, a definite contraction was noticed in the thigh muscles of the opposite leg.

X-rays disclosed a most unusual type of fracture, best characterized by one of our colleagues who saw this patient in consultation as an "explosion" fracture.

The roentgenograms showed a comminuted fracture of the body of the fourth lumbar vertebra. The fracture had sheered off in such a way that the lower anterior portion of the body with the fifth lumbar vertebra had been displaced anteriorly, so that it lay in front of the spinal column proper, and part of it above the lower quarter of the third lumbar vertebra. The sacrum, while partially pushed forward, had not been displaced as far as the body of the fifth lumbar vertebra and, therefore, had encroached upon the space normally occupied by this vertebra. There was also a fracture of the sacrum, approximately at the level of the third segment, with the lower segment slightly anterior.

It became apparent that the injury had widened and shortened the spinal canal sufficiently to prevent the involvement of the roots of the corda equina. An attempt at closed reduction of this fracture might well result in a permanent derangement of the involved fibers of the spinal cord as well as in damage to the aorta. There was likewise relatively little chance that satisfactory reduction could be obtained by operative procedure. As the general alignment of the spine shown in the anterior, posterior, and lateral planes was relatively good, it was decided to immobilize the patient and await results. Since it was quite probable that a stable back would not result, the advisability of doing a bone-graft-fixation operation over the fractured area at a later date was given consideration.

Following the method adopted in the previous case, the plaster shell, incorporating both legs to the knees, was molded on the patient. The distention and urinary retention

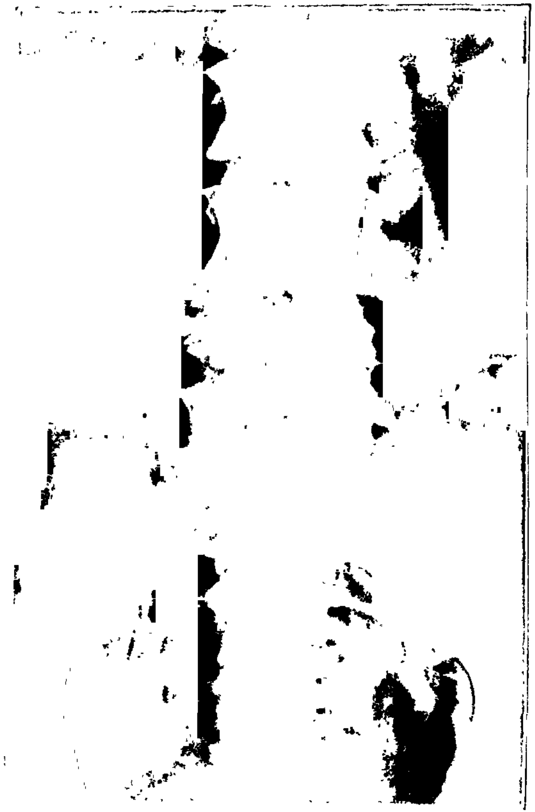

Fig. 5

Case 2, A. D. Anteroposterior view of lumbar spine, showing absence of gross deformity.

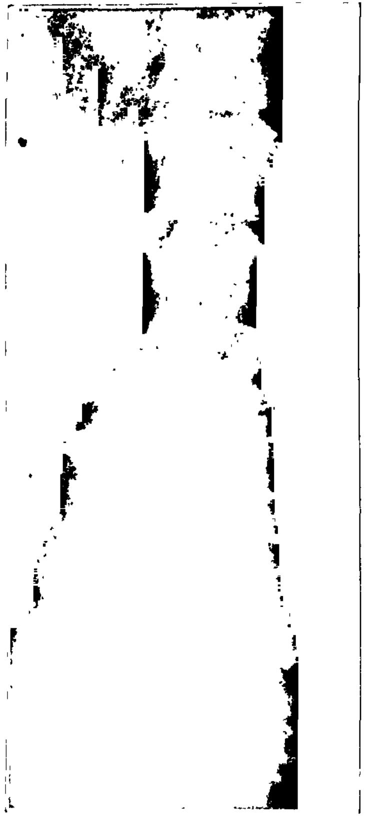

Fig. 6

Case 2, A. D. Lateral view, showing marked displacement and "explosion" of the vertebrae.

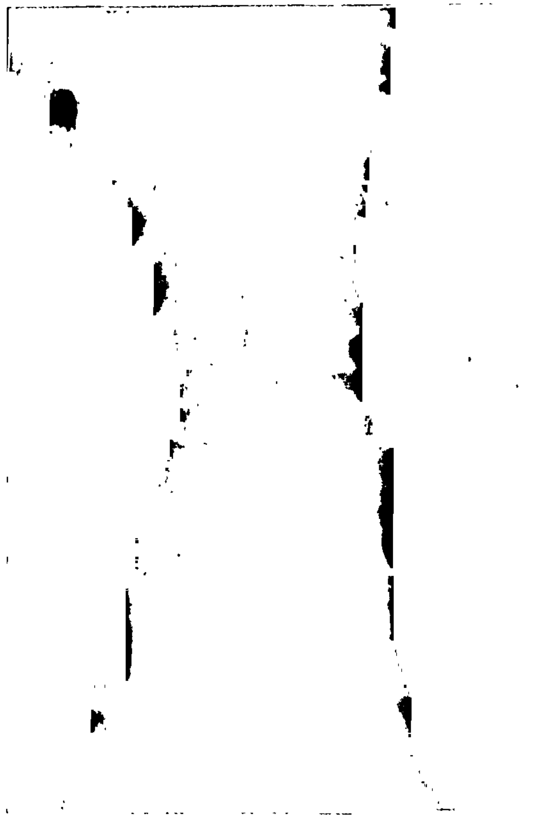

Fig. 7

Case 2, A. D. Five months later. Deformity unchanged; patient ambulatory; no symptoms.

disappeared within a few days and the patient progressed in apparently uneventful convalescence.

As soon as immobilization was secure, the patient was turned frequently on the abdomen and side to avoid congestion and possible pressure sores. The authors have adopted this method as a routine measure in the treatment of spinal injuries, and they have found it to be not only a very valuable adjunct in the treatment of the condition mentioned, but also a direct prophylaxis against tympanites and its altogether too frequent companion, paralytic ileus.

The plaster was changed about the fourth week and a well fitting shell was carried to the level of the trochanters only. This plaster was retained until December 28, 1934, some three and one-half months following the accident. At this time a spinal brace was applied, new x-rays were taken, and rehabilitation exercises were started.

The oblique x-rays of the lower lumbar spine showed the fracture of the fourth and fifth lumbar bodies to be well organized, with much callus. There was no definite bony union between the sacrum and the fifth lumbar vertebra.

Exercises in bed were given for about two weeks, followed by ambulation for increasing periods. At present, the patient is up the entire day and is able to walk about without aid, to climb stairs, and to get in and out of an automobile without great difficulty. His most outstanding impediment has been the limited motion in the hip joints, which has prevented him from sitting comfortably, except in chairs of sufficient height to compensate for the loss of hip flexion. This motion is now entirely recovered, and the patient is exercising several hours a day without support of any kind. He is still wearing the spinal brace, which he is removing for increasing periods and which will shortly be dispensed with entirely. Aside from general fatigue, which is natural after his increasing activity, he has no complaints that are referable to the injury.

CONCLUSIONS

1. No standardized treatment can be adopted for complicated spinal injuries; the amount of corrective procedure necessary is dependent upon the surgeon's judgment in the individual case.

2. The combating of shock and the preservation of the patient's life take precedence over orthopaedic corrective measures.

3. The question of surgery for the alleviation of nerve injury must be decided for each case individually.

4. The restoration of anatomical position is not absolutely essential for the obtaining of a good functional result.

5. In those cases in which open operation is resorted to, it is advisable to fuse the fractured area at the time the original operation is performed.

6. Frequent turning and changing of the patient's position, as soon as adequate immobilization has been obtained, is of primary importance in avoiding complications, such as pressure sores, pulmonary changes, and ileus.

CORTICAL AVULSION FRACTURE OF THE LATERAL TIBIAL CONDYLE

BY HENRY MILCH, M.D., F.A.C.S., NEW YORK, N. Y.

*From the Hospital for Joint Diseases**

During the past few months, the author has had the unusual opportunity of examining several fractures of the knee in which the whole clinical picture presented such a constant and striking uniformity as to warrant grouping these fractures in a special category. At the outset, the diagnosis could be established only by means of the x-ray, but more careful study of the clinical picture has shown that the diagnosis may be ventured and should always be entertained even before the roentgenogram has been made.

The following cases are of special interest because they present in ascending order the various degrees in which the condition, cortical avulsion fracture of the tibial condyle, may be met.

CASE 1. M. P., a physician, was seen a day or two after he had misstepped and fallen on his flexed right knee. At the time of the injury, he complained of severe pain and had to be picked up and carried back into the house. After a day or two, the pain gradually subsided, but the patient noted difficulty in going up stairs.

When examined, no fluid was found in the knee and no ecchymosis was seen. There was no limitation nor abnormality of motion. There was a point of tenderness definitely

FIG. 1

Oblique anteroposterior view, showing oval shadow directly below area of tenderness.

FIG. 2

Anteroposterior view, showing cortical avulsion fracture involving the articular surface of the tibia. The head of the fibula presents its normal contours.

* Service of Harry Finkelstein, M.D.

localized over the lateral condyle of the tibia just below the articular edge in a plane midway between the tibiofibular joint and the tibial tubercle. This area corresponded roughly with the area behind Gerdy's tubercle, described by the French anatomists.

On the basis of this localization of pain, a tentative diagnosis of a sprain fracture was made and an x-ray was ordered. This was reported by Dr. Pomeranz as showing a small oval shadow which was situated just beneath the tender area and probably represented a sprain fracture with incomplete separation of the fragments (Fig. 1.) In view of the fact that the symptoms were subsiding, no treatment was considered necessary.

CASE 2.* C. S., a male, aged sixty-five, was admitted to the Hospital in June 1928. He had been struck by an automobile while crossing the street two days previously and was unable to rise or to walk on the affected left limb.

On admission to the Hospital, there was marked tenderness over the external condyle of the left tibia with moderate effusion into the knee joint. There was no lateral instability and no anteroposterior mobility.

The x-ray reported by Dr. Pomeranz showed a complete longitudinal fracture of the external condyle of the tibia at its outer aspect, involving the joint. There was a separation of a small shell-like fragment of bone, as well as an incomplete oblique fracture at the base of the posterior crucial spine, with separation of the fragments.

The following day the knee joint was aspirated and forty cubic centimeters of bloody fluid, containing free fat globules, was aspirated, and a posterior plaster-of-Paris splint was applied. One week later, a plaster-of-Paris bandage was applied with the knee in 175 degrees of extension. Following removal of the cast, the patient made an uneventful recovery.

FIG. 3

Anteroposterior view, showing small fragment detached from the tibial surface. The head of the fibula is normal.

CASE 3. R. G., a male, aged twenty-five, was seen on May 1, 1935. He had fallen on his flexed right knee some four days previously. There was a history of an injury to the same knee received some years ago while playing football. Although there had been occasional attacks of locking, the knee apparently had caused no recent symptoms.

On examination, the knee was found to be markedly swollen. Extension was limited to 160 degrees; flexion, to 90 degrees. There was a marked degree of anteroposterior and lateral mobility, especially on abduction. Pressure over the femoral attachment of the tibial collateral ligament elicited tenderness. In addition, there was marked tenderness over the external tibial condyle just above and medial to the head of the fibula.

X-ray of this area (Fig. 3) showed a characteristic cortical fracture of the external condyle of the tibia. It was apparent, however, that this injury was of minor importance in comparison with the other injuries to the ligaments of the knee joint.

At operation, the anterior crucial ligament was found to be torn just above its tibial attachment, and was resected. The internal semilunar cartilage was found to be detached from the tibia, and this, too, was excised. The joint was closed. The tibial collateral ligament was then exposed extra-articularly and a long transverse tear in its femoral attachment was sutured and reenforced by overlapping. A plaster-of-Paris bandage was applied. Uneventful convalescence followed.

*The author is indebted to Dr. H. Sonnenschein for the privilege of reviewing this case.

Each of these patients gave a history of injury with the knee in flexion. In the first case, that of an incomplete fracture, there was localized tenderness, a suggestive roentgenogram, and a transitory interference with function. In the second case, in addition to these symptoms, there was a marked hemorrhagic effusion into the joint. In spite of this, there was no evidence of any lateral hypermobility. In the third case, there was increased lateral mobility, but this was attributed to the presence of the other ligamentous lesions rather than to the cortical fracture. That this was the case is evidenced by the fact that the lateral instability disappeared promptly upon suture of the tibial collateral ligament.

The presence or absence of lateral hypermobility appears to be an important point in the differential diagnosis of cortical fractures. Thus, a fracture of the tibial condyle or a sprain fracture of the head of the fibula might give essentially the same clinical picture of injury to the flexed knee as does cortical fracture of the tibial condyle, and might result in localized tenderness with or without effusion. Apart from the roentgenogram, the presence of abnormal lateral mobility on adduction would suggest the former of these two conditions, while its absence would tend to support the diagnosis of cortical fracture. This is the more significant when it is realized that the roentgenographic appearances of sprain fracture of the head of the fibula and cortical fracture of the tibial condyle may be quite similar, as the following case demonstrates.

Fig. 4

Anteroposterior view, showing marked similarity to Figure 3. It is to be noted that there is a definite irregular concavity in the head of the fibula. Clinically, the patient presented signs of preternatural adductibility of the leg on the femur.

Case 4. D. D., a female, aged twenty-eight, was seen in the Out-Patient Department four weeks after an automobile injury. There was marked tenderness on pressure over the lateral condyle of the tibia. There was some limitation of flexion and extension, but the striking point in the clinical picture was that the leg could be abducted on the femur beyond the normal range. On the basis of this finding, a diagnosis of fracture of the head of the fibula, or of the external tibial condyle, was tentatively made. X-ray showed a chip fracture of the head of the fibula with slight separation of the fragments (Fig. 4).

If Figure 4 be compared with Figure 3, great similarity will be noted, and only careful study will demonstrate the fact that the free fragment of bone is derived from a small concavity in the head of the fibula.

In evaluating the roentgenographic evidence of this type of cortical fracture, the position of the leg is of the utmost importance. In Figure

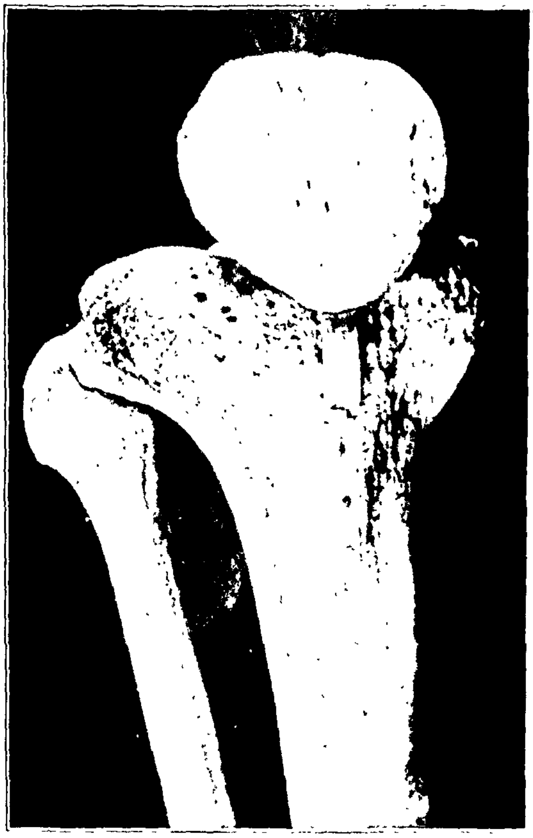

Fig. 5-A

Photograph of a tibia in which the area of avulsion fracture is shown in dark ink.

Fig. 5-B

Shows the same area rotated so that in profile it appears to lie over the head of the fibula. This is the best means of separating the shadow cast by the fracture from that due to the tibia. In roentgenography, the tube should be directed anteriorly and medially sufficiently to project the shadow of the tender area beyond the head of the fibula.

5-A, the area which is customarily avulsed is shown by the dark shadow. It will be noted that, unless there is marked separation of the fragments, the shadow cast by the fractured area must be superimposed upon the shadow cast by the outer half of the tibial condyle and thus be rendered inconspicuous. In order that the shadow may be thrown away from that of the tibial condyle, the exposure must be oblique, as was attempted in Figure 1. On the other hand, when this is done, the fractured area seems to lie just above the fibular head (Fig. 5-B), and the conclusion may be drawn that the fragment is derived from the head of the fibula rather than from the lateral aspect of the external tibial condyle.

In reviewing the literature, the author could find no clinical information on this interesting lesion. By accident, a reference to the experimental work of Segond was noted. Though no clinical cases are cited in this work, it appears that, in studying the effects of rotation, Segond accurately described the pathology of the type of cortical avulsion fracture which has been mentioned. Briefly summarized, the conclusions to which Segond came as a result of his experimental work are as follows:

Neither external nor internal rotation can take place with the knee in

extension. With the knee in this position, rotation is converted into forced abduction or adduction and results in the usual type of injury to the crucial and collateral ligaments of the knee joint. With the knee flexed to 145 degrees, either internal or external rotation can take place. If the knee is rotated internally, tension is noted in the lateral and crucial ligaments, but the site of maximum tension is at a point beyond and behind Gerdy's tubercle, where the articular capsule is reenforced by the insertion of the femoral aponeurosis. At this point, there is found "a pearly, fibrous, resistant band of tissue which in all motions of internal rotation undergoes a marked degree of tension".

This is the area of the external tuberosity shown by the dark shading in Figure 5-A. It is described by Rouvière as presenting: (1) posteriorly and externally, an articular facet, smooth, rounded, facing downward,

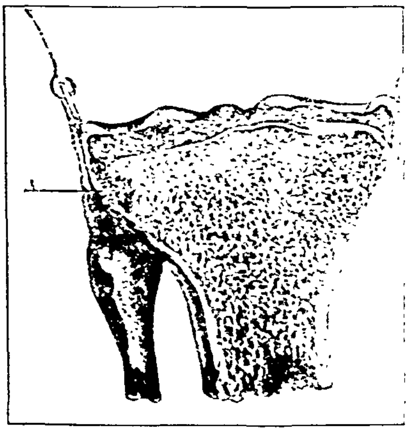

FIG. 6-A

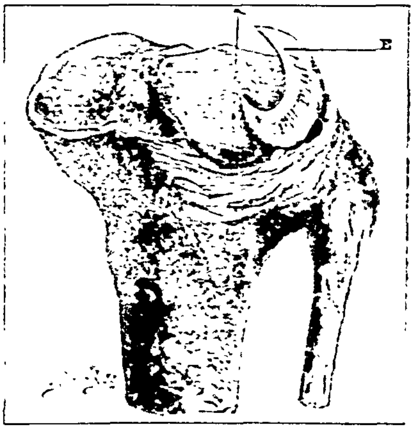

FIG. 6-B

Original drawings from Segond's article, showing the pathological site of the fracture and its relation to the edge of the external semilunar cartilage. (*Reproduced by courtesy of Le Progrès Médical.*)

backward and outward—the peroneal facet for the articulation with the head of the fibula; (2) in front and externally, the tubercle of Gerdy; (3) in front and below, an oblique crest extending from the tubercle of Gerdy to the external border of the tibial tuberosity and, with the tubercle of Gerdy, affording insertion to the tibialis anticus and the tensor fasciae femoris muscles. Lewis, in Gray's Anatomy, describes this area as follows: "Its lateral surface is convex, rough, and prominent in front: on it is an eminence, situated on the upper border of the tuberosity and at the junction of its anterior and lateral surfaces, for the attachment of the iliotibial band."

As a consequence of the marked tension on this "pearly band" of resistant tissue (the insertion of the iliotibial band), the site of insertion tears out. In thirty-eight experiments, Segond was able to produce the lesion seventeen times. In fourteen instances, the tear was complete and in the others, incomplete. He pointed out that in the milder cases, as in

Case 1 described in this paper, the lesion might exist by itself without having caused an opening into the joint. In the more complicated cases, it might be associated with tearing of the synovial membrane and injuries to the other ligamentous structures of the knee, as in the author's Cases 2 and 3. The lesion is remarkably constant in site and appearance. It usually consists of a small cavern in the spongy tissue of the external condyle of the tibia. This cavern varies in depth from five to ten millimeters. It usually communicates with the interior of the knee joint by a small slit like a buttonhole, which is hidden beneath the anterior edge of the external semilunar cartilage (Fig. 6). When the lesion is very small, it may not communicate with the joint. When the fracture is severe it never extends anteriorly beyond the tibial tubercle or posteriorly beyond the tibiofibular articulation.

This avulsion is caused by tension on the iliotibial band at its insertion into the area behind Gerdy's tubercle. It is usually acquired by injury, with the knee in the partly flexed position, but it may also be produced with the knee in the fully flexed position, if the heel is held medially to the axis of the femur during the internal rotation of the leg. Apart from the mechanism of its production, the characteristic features of the condition are the localization of the tenderness, the sudden development of a traumatic hemarthrosis, and the characteristic roentgenographic appearance. In discussing the question of the hemorrhagic effusion into the joint, Segond quoted Ficatier, who first pointed out the significance of the fat in sprains of the knee. Like Kling, who discussed this matter later, Ficatier was of the opinion that fat found in repeated aspirations from a knee joint indicated quite certainly the presence of an intra-articular fracture.

The treatment of the condition is symptomatic. If necessary, the effusion should be aspirated repeatedly. The leg may be put at rest either in a cast or on a posterior splint, if the separation of the fragments is sufficient. If no separation of the fragments has occurred, simple rest or strapping of the area is sufficient. Physiotherapy is indicated.

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TUNICA VAGINALIS IN ARTHROPLASTY OF SMALL JOINTS*

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Since synovial membrane is the normal lining of a joint cavity except where cartilage exists, it appears that in reconstructing a joint cavity the membrane used should be histologically as nearly identical with the synovia as possible. Tunica vaginalis resembles the synovia histologically and also functionally in its ability to secrete a fluid, and the author believes it should be used more generally in preference to other tissues now commonly employed. Such use of the tunica vaginalis is not original. Flaps taken from hydroceles and peritoneum from hernia sacs have been employed many times previously.

Before using tunica vaginalis in arthroplasty in human beings, it was used experimentally in eight dogs for reconstruction of the knee joint and for producing a pseudarthrosis in the leg. Five of these dogs were followed for a period of four months. The joints were examined *post mortem*, and, in all, the tunica vaginalis was found to form a thin membrane over the end of the bone. In the cases of pseudarthrosis, the membrane was placed over one end of the cut bone, the other cut end being left uncovered. In each case, no effort was made to prevent the dog from bearing weight on the leg. At the end of four months, the new joint cavity was found to contain a moderate amount of clear straw-colored fluid which was sterile. The end of the bone on which the tunica vaginalis had been placed was round and smooth and covered with a membrane resembling synovia. The other end of the bone, not originally covered with a membrane, had been thrown out in a roughened, irregular formation. It had not yet become overlaid with a fibrous covering, as is supposed to be the case in arthroplasty without the use of some soft-tissue transplant.

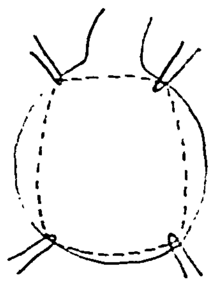

FIG. 1

Four sutures are placed in the tunica vaginalis before it is removed from the testicle in order to aid in placing it in the new field without trauma from forceps.

When fascia lata or other tissue is used, the interposed tissue loses its specific characteristics and is transformed into a tissue which, in part, forms the new capsule and, in part, the lining membrane of the joint capsule and the bony surface. This layer of interposed tissue, while transformed into a fibrous covering of the bone, never attains a degree of differentiation as does the living cartilage or synovia, although functionally it appears to replace it fairly satisfactorily.

* The experimental work described in this paper was done at the University of Maryland School of Medicine and College of Physicians and Surgeons.

If the interposed tissue is to resemble the synovial lining of a normal joint, it should have a structure and function similar to the synovial membrane. The normal synovial membrane is a special structure, the function of which is to produce a lubricating fluid. As has been stated, the tunica vaginalis resembles the synovial membrane histologically, as well as functionally in its ability to secrete fluid. Unfortunately, it is available as an autogenous transplant only in the male. It is also limited in amount, so that it can be used only for the hip joint and the smaller joints of the body. In the case of a normal tibiofemoral articulation, when the patella is ankylosed to the femur, a free transplant of tunica vaginalis will give a covering for the raw bony surface which closely resembles the normal synovia present in the knee joint. In the jaw, wrist, metacarpal and phalangeal joints, this material is satisfactory as its thinness and elasticity make it easy to suture. If four sutures are placed in the tunica vaginalis before it is excised, it can be handled with more ease and less trauma and can be placed easily in its new field. For the larger joints such as the knee, fascia lata is more suitable, because it can be obtained in sufficient quantities to cover the entire denuded surfaces.

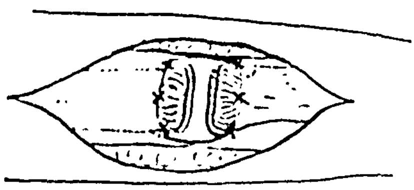

FIG. 2

Diagram illustrating arthroplasty of the phalangeal joint through lateral incisions, in which *tunica vaginalis is used as a covering* for the reconstructed joint surfaces.

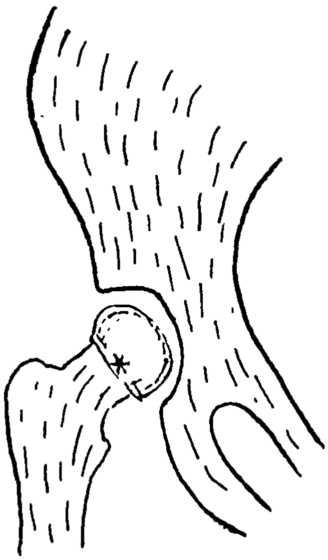

FIG. 3

Covering of reconstructed head of the femur with tunica vaginalis in arthroplasty of the hip.

Since 1929, the author has used tunica vaginalis clinically in a limited number of cases.

CASE REPORTS

CASE 1. A young colored man, thirty-two years of age, came to the hospital with ankylosis of both hips of some years' standing, secondary to an infective arthritis. The arthritis was apparently quiescent and had shown no activity for over a year.

An arthroplasty of the right hip joint was done. The fibrocartilage over the head of the femur was removed and also the fibrocartilage covering the acetabulum. After the hip joint had been prepared for the transplant, an incision was made in the inguinal region just below the external inguinal ring and the testicle was made to present through this incision. The tunica vaginalis was distended with saline until it was about three times its normal size. It was then excised, slipped over the reconstructed head of the femur, and held in place with catgut sutures. The thin tunica vaginalis fitted snugly over the reformed bone without wrinkling. The inner secreting layer of the tunica vaginalis was placed to form the joint cavity, the fibrous layer being next to the denuded bone. The acetabulum was left uncovered. The right leg was placed in traction to prevent the new joint surfaces from coming in contact, and motion was started on the third day after operation.

The results were only fair. Motion of approximately 75 degrees was obtained, which allowed the patient to walk about, although the joint was not entirely painless.

CASE 2. A man, forty-three years of age, came to the hospital with an old compound fracture of the distal end of the radius. The displaced head had dislocated posteriorly and had healed in a position which prevented dorsiflexion of the wrist.

The distal end of the displaced radius was excised and the denuded area was covered with tunica vaginalis. Healing progressed satisfactorily. Motion of the wrist was limited by approximately 20 degrees, apparently due to adhesions about the wrist joint at the time of the original compound fracture.

CASE 3. A man, twenty-eight years of age, suffered from fibrous ankylosis of the second metacarpophalangeal joint of the right hand, following fracture of the distal end of the metacarpal bone.

The head of the metacarpal bone was excised, leaving a concave surface as is done in the tibia in reconstructing the knee joint. A piece of tunica vaginalis was placed over the end of the denuded metacarpal bone. The hand was placed in a banjo splint with the finger in traction. On the third day after the operation, motion was started with traction in place to prevent recurrence of adhesions between the tendons and the periarticular tissues.

Recovery was satisfactory, with a range of motion from full extension to 60 degrees of flexion. This is approximately 30 degrees less than the joint can normally be flexed.

CASE 4. A man, forty-six years of age, had received a fracture-dislocation of the proximal head of the right radius. As a result of this fracture, there was a proliferation of new bone anteriorly which not only limited supination of the forearm, but flexion and extension of the elbow as well.

Through the usual incision, the fractured dislocated head of the radius, together with the new bone about the area, was removed as cleanly as possible. The raw surface was covered with a piece of tunica vaginalis.

Recovery was uneventful. Motion was started the fifth day after operation. Motion progressed satisfactorily with approximately 10 per

FIG. 4

Pseudarthrosis in a dog's leg four months after the distal end of the bone was covered with tunica vaginalis. The proximal end (1) was not covered and irregular growth of bone occurred. The end covered with tunica vaginalis (2) was smooth and protected with a thin, shiny, moist membrane resembling synovia. The new joint surface contained a small amount of sterile fluid resembling synovial fluid.

cent. permanent limitation of supination. There was no limited motion of the elbow joint, and movements were painless.

CASE 5. The patient was a man, twenty-three years of age, with ankylosis of the second metacarpophalangeal joint which followed a crushing fracture of the proximal phalanx of the finger.

An arthrotomy was done and the cartilage was removed from both the metatarsal head and the proximal end of the first phalanx. The area was covered by a flap of tunica vaginalis. The graft covered both the raw surface of the metacarpal bone and the phalanx. The finger was placed in traction and motion was started the fifth day after operation.

This treatment resulted in 60 degrees of flexion, but some lateral instability of the joint.

CASE 6. A man, forty-eight years old, sustained a fracture of the proximal end of the radius with anterior displacement of the head. He refused operation at the time of injury, but later, because of the limited painful motion of the elbow joint, submitted to operation. At that time, there was little supination and only about 40 degrees of motion in the elbow joint. The dislocated head of the radius was removed, together with the newly formed bone about that area. The end of the radius was covered with a graft of tunica vaginalis.

Recovery was satisfactory. There was slight residual loss of supination. Movements of the elbow joint returned to normal and were painless.

SUMMARY

Experimentally in dogs and clinically in human beings, tunica vaginalis has been found to be a suitable membrane for covering raw surfaces in arthroplasty of the smaller joints.

The secreting surface of the tunica vaginalis is turned toward the joint cavity and the fibrous elastic layer is placed against the denuded bone surface.

It is believed that, in male patients, the tunica vaginalis is the most satisfactory interposing membrane which can be used in arthroplasty of the small joints.

SURGICAL MANAGEMENT OF PES CALCANEUS *

BY O. L. MILLER, M.D., CHARLOTTE, NORTH CAROLINA

The degree of deformity present in paralytic calcaneus is dependent upon the extent of muscle imbalance at the ankle. Recovery after infantile paralysis may leave the posterior group of leg muscles only slightly weaker than the anterior group, with moderate imbalance and mild calcaneus. On the other hand, the posterior group of leg muscles may be completely paralyzed, resulting in extreme calcaneocavus, marked imbalance, and frank heel-walking. There may also occur weakness or complete paralysis of the inner or outer lateral group of muscles at the ankle, in addition to the involvement of the posterior group, with resultant calcaneovalgus or calcaneovarus. It is fortunate that certain muscles whose tendons pass about the ankle are frequently not involved in the paralytic distribution and are available for transplantation into the defective tendo achillis in a foot with calcaneus deformity.

In doing a foot-stabilization operation for correction of calcaneous deformity, substantial sections of bone must be removed from the upper surface of the os calcis and the lower surface of the astragalus. Successful correction of this deformity depends upon ample resection of these masses of bone, so that the architecture of the foot will be entirely changed in its relation to future weight-bearing. The neck of the astragalus should be sectioned and the head should be removed, so that it and the opposing scaphoid may be thoroughly denuded of cartilage. The calcaneocuboid joint should be resected and the planter fascia should be sectioned. As the wound is closed, the head of the astragalus is put back in its bed or placed laterally or medially to its former position, depending upon whether varus or valgus of the forefoot is to be corrected. When the operation is completed, the entire foot should be shifted backward and upward on the astragalus. The extremity is then dressed in plaster with the foot in moderate equinus and the knee slightly flexed. In this position, recovery of any latent power existing in the gastroenemius, soleus, or other retromalleolar muscles is encouraged. While the plaster cast is setting, firm pressure should be applied to the sole of the foot in order to stretch the plantar structures as much as possible.

In mild deformities, a calcaneus type of foot-stabilization operation may be all that is necessary to effect satisfactory balance, but, in the more severe types, both stabilization and tendon transplantation are indicated. The principal tendons available for transplantation to reenforce the Achilles tendon, in order of value and availability, are: the peroneals, the posterior tibial, the anterior tibial, and the long toe extensors.

Five weeks after the stabilization operation has been performed, the

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

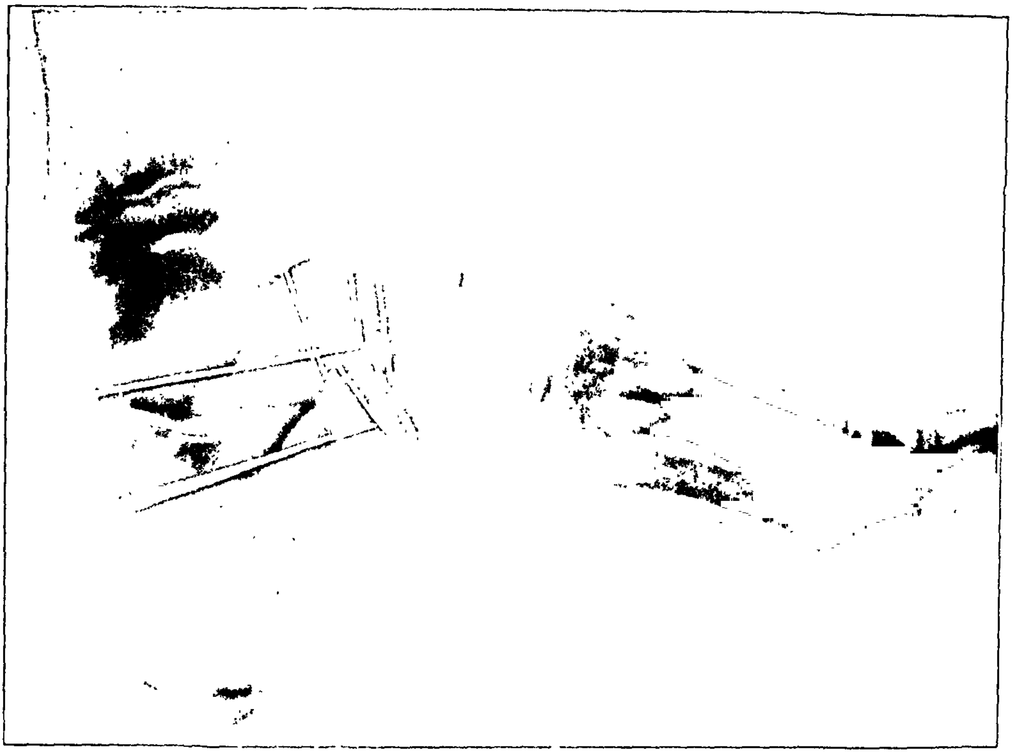

FIG. 1

Illustrating the substantial wedges of bone to be removed from the opposing surfaces of the bodies of the os calcis and astragalus in the correction of calcaneus deformity.

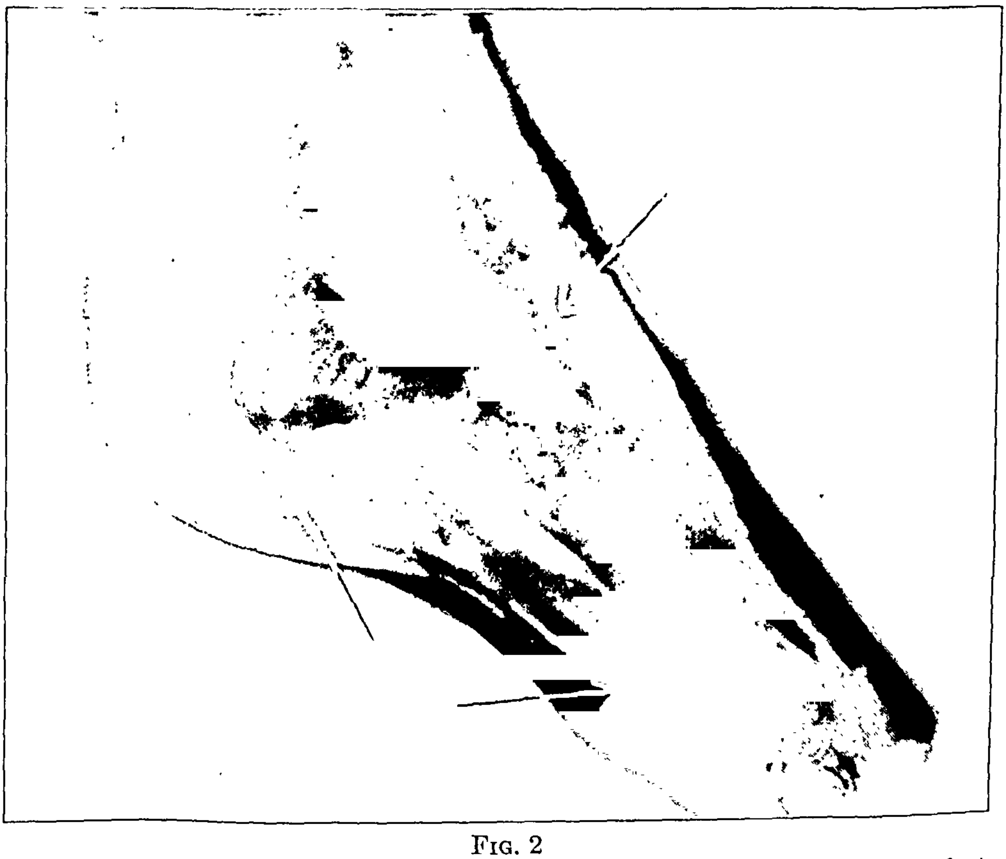

FIG. 2

Position in which the foot should be dressed following a calcaneus type of foot stabilization. The same position should also be used after manipulation.

Fig. 3

Illustrating the improved relations of the bones of the foot after a calcaneus type of foot stabilization.

Fig. 4

Posture of foot five years after a calcaneovarus type of stabilization and transplantation of the tibialis posterior tendon into the tendo achillis.

cast should be removed for a refining manipulation of the foot. After manipulation, another snug cast should be applied to the leg. Firm pressure should be exerted on the sole of the foot as before, thrusting the os calcis upward and backward. With the addition of a plaster-heel extension to the cast, the patient may be allowed weight-bearing after manipulation, since the forces so expended will be corrective.

Postoperative massage and physiotherapy should be instituted seven weeks after operation, and weight-bearing in a high shoe should be permitted about two weeks later. If the heel of the shoe is broadened at its base and slightly raised, it will serve as a protection to the foot in its new position and will improve the gait. As pointed out by Hoke in his early work on stabilization of paralytic feet, the criterion of a successful surgical result is a foot that looks natural in a shoe and is stable when the patient is standing or walking. Such a foot should not require a brace.

The observations in this paper are based on experience with seventy-five foot-stabilization operations for calcaneus deformity. The feet were classified as: mild calcaneus, thirteen; calcaneocavus and valgus, fifty-three; calcaneovarus, nine. The average age of these patients at operation was eleven years. Tendon transplantation supplemented the foot stabilization in thirty-seven cases. The peroneus longus and peroneus brevis tendons were transplanted into the tendo achillis in twenty-eight cases; the peroneus longus and the tibialis posterior tendons, in three; the peroneus longus and the tibialis anterior tendons, in two; the tibialis anterior and the extensor digitorum longus tendons, in two; the tibialis anterior tendon, in one; and the tibialis posterior tendon, in one.

FIG. 5-A FIG. 5-B

Fig. 5-A. Appearance of foot before operation.
Fig. 5-B. After stabilization operation.

SUMMARY

A reasonably successful result attending the surgical management of calcaneus deformity depends upon: (1) accurate evaluation of the bony and muscular pathology; (2) the correction of overgrowth and disturbed relations in the depth of the os calcis and astragalus by a calcaneus type of foot stabilization; (3) the dressing of the foot in an overcorrected position after operation and after manipulation; (4) the best possible balancing of muscle pull where tendon transplantation is indicated; and (5) careful direction of early weight-bearing in properly built shoes.

THE TREATMENT OF CLUB FEET *

BY LLOYD T. BROWN, M.D., BOSTON, MASSACHUSETTS

The following method of treatment of congenital club feet has made it possible to get useful feet and legs without the use of forcible manipulation, ether, tenotomies, repeated plaster casts, or adhesive-plaster strapping to the whole foot and leg. Naturally the earlier the treatment is begun the better.

It is well known that continuous traction will gradually tire out a muscle; that a contracted muscle put on the stretch will gradually lengthen; and that a stretched muscle, if relaxed, will shorten so that it can get back to a position in which contraction can occur. These principles can be applied to the problem of club feet in the following manner.

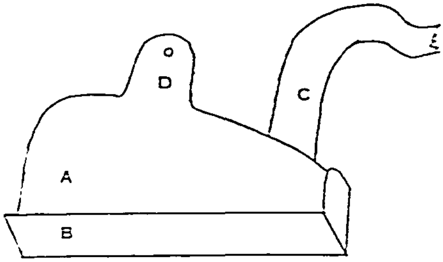

FIG. 1-A

Aluminum foot plate as seen from above.
A: Sole plate.
B: Inner border of sole plate turned up at a right angle.
C: One-half-inch binding tape, at least three feet long, fastened to sole plate.
D: Projection or outrigger attached to the outer side of sole plate to which is attached the elastic traction.

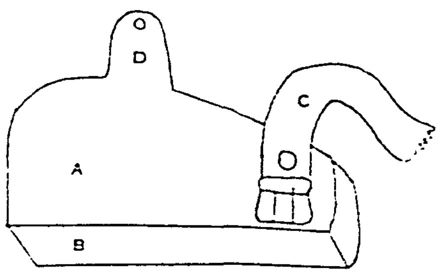

FIG. 1-B

Aluminum foot plate as seen from below. Note the buckle at the sole-plate end of the tape.

For the very young—a few days to a few weeks old—an aluminum foot plate (Figs. 1-A and 1-B) is made a little longer than the foot and the same width. The inner border of this plate is turned up at a right angle to the sole so that it is just higher than the dorsum of the great toe joint; this upturned border is carried around behind the heel. To the sole plate at the posterior end is attached a piece of soft binding tape, one half an inch in width and at least three feet in length. On the outer side of the sole plate is a projection to which can be applied the elastic bands for traction. The foot is placed on the sole plate and bound to it without any attempt to get correction. The important point is to get the heel and the foot firmly attached to the plate. The binding tape should cover the whole foot with a figure-of-8 around the ankle.

To the anterior outer side of the thigh, just above the knee joint, is applied a small piece of adhesive plaster, two by two inches; the exact

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

Case 1. Male, aged five years, with bilateral club-foot. In spite of much treatment with adhesive and plaster casts, there had been several recurrences. The patient was seen in April 1934, because lengthening of the Achilles tendon had been advised, with possible arthrodesis of the subtalar joint.

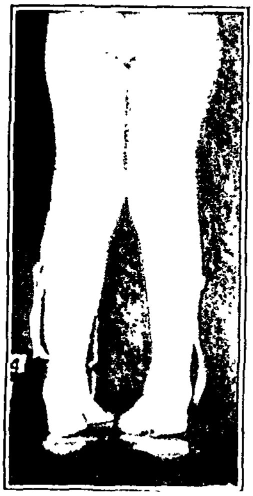

Fig. 2-A

Fig. 2-A: Posterior view, April 9, 1934.

Fig. 2-B: Lateral view, April 9, 1934. Note position of the os calcis and the heel cords; the heels *do not* come to the ground. Note the knock-knee. The patient walks on his toes and turns the feet in, particularly the right foot. Otherwise, the feet are very limber and easily overcorrected.

The right foot cannot be flexed within 25 degrees of a right angle and the left, within 20 degrees.

The patient was fitted to plaster-of-Paris night shoes with the feet in the best corrected position, and elastics were added to the day shoes.

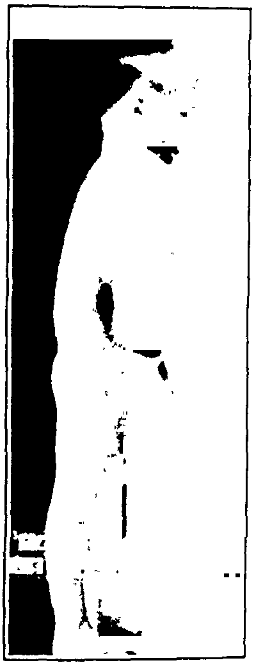

Fig. 2-B

Fig. 2-C

Fig. 2-D

Fig. 2-E

Fig. 2-C: Posterior view, June 28, 1934. Note position of heels.

Fig. 2-D: Lateral view, June 28, 1934. Note the amount of dorsiflexion possible with no back-knee deformity.

Fig. 2-E: Anterior view, June 28, 1934.

Fig. 2-F

Fig. 2-F: Posterior view with weight, December 12, 1934. Note overcorrection of the os calcis.

Fig. 2-G: Lateral view without weight, December 12, 1934. Note possible correction of equinus.

Fig. 2-G

position and size are chosen with reference to the amount and the direction of the traction desired. Traction is made between the sole plate and the adhesive plaster on the thigh with only two small rubber bands such as come around checks. It is *continuous* day and night, being removed only for bathing, gentle manipulation by the mother, and changing the adhesive plaster. The use of adhesive plaster can be kept up for months without skin irritation by changing its position on the thighs from time to time.

It is interesting to note that, when traction is applied, the stronger muscles usually begin to work, but, every time they relax, the foot is pulled into a more correct position so that there is a continuous slight corrective force being applied. For this reason, it is not necessary to use more than two elastic bands.

With a larger foot, the same type of traction can be applied by means of a plate attached to the sole of a shoe. The shoe should be laced and should be a half inch to an inch longer than the foot and the same

Fig. 3-A

Case 2. Male, aged four days, with bilateral club-foot. Neither foot could be corrected.

Fig. 3-A: Photograph, February 24, 1928.

Fig. 3-B: Anterior view, May 21, 1934.

Fig. 3-C: Posterior view, May 21, 1934.

Note size and shape of the lower legs, the line of the Achilles tendons, and the shape of the feet.

The treatment consisted of an aluminum splint with elastic traction day and night, until overcorrection was obtained. Then a shoe was worn with the elastic traction day and night for two years, until the child was walking. This shoe was then worn only at night. If there is any tendency to recurrence in such a case, the night traction should be kept up for several more years.

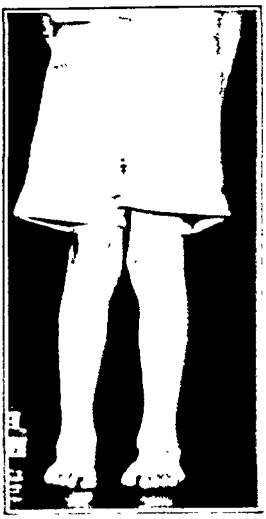

Fig. 3-B

Fig. 3-C

Fig. 4-A

Case 3. Male, aged two weeks. Bilateral congenital club-foot with marked adduction and equinus; practically no heel and very tight heel cords. Both feet were so rigid that no more than one-half correction was possible.

Fig. 4-A: Before treatment, October 31, 1934.

Fig. 4-B: Photograph taken in December, 1934, showing splints applied with elastics to thigh.

Fig. 4-C: Photograph, January 23, 1935, showing application of elastic traction with shoes. This traction can be used when correction of the deformity has been obtained.

Fig. 4-B

Fig. 4-C

Fig. 5-A

Case 4. Male, aged three months, with *unilateral club-foot* (right). The twin brother of this child had no deformity.

Fig. 5-A: Photograph, January 12, 1931. The varus *cannot* be corrected and the foot is rather stiff.

Fig. 5-B and Fig. 5-C: Photographs, March 23, 1931, showing shoe and elastic traction.

Fig. 5-D: Photograph, May 23, 1934, three years later. Note the size and shape of the foot and the lower leg.

Fig. 5-B

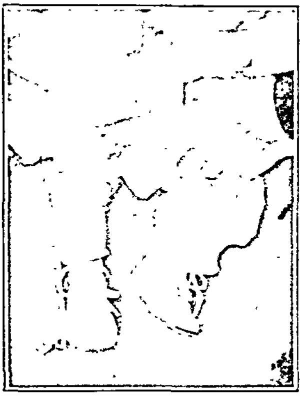

Fig. 5-C

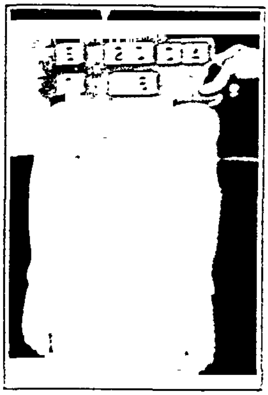

Fig. 5-D

width as the foot. This traction should also be continuous, day and night.

In older children, the continuous traction can be replaced at night by a bivalved plaster cast from toes to just below the knee. The night protection, whether it be with a cast or with the traction apparatus, is of the greatest importance and should be used for a long time,—several years if there is any tendency to recurrence, as is so common during the growing period. The day traction does not need to be used after full correction of the deformities has been obtained.

SUMMARY

It has been found possible and simple to obtain marked overcorrection of all the deformities of club feet by the use of continuous slight traction by means of elastic bands. Since this method has been followed, it has not been necessary, in children up to the age of five years, to use forcible manipulations, ether, tenotomies, or stretching by frequently changed plaster casts or adhesive plaster.

USE OF FASCIA LATA TO STABILIZE THE KNEE IN CASES OF RUPTURED CRUCIAL LIGAMENTS

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In severe lacerations of the knee, the usual finding is rupture of both crucial ligaments and one of the two collateral ligaments. Both collateral ligaments are rarely ruptured, as the force causing the injury is generally from the side and the knee is straight. The medial ligament is usually the one that is injured. Several methods of repairing the crucial ligaments have been advocated.

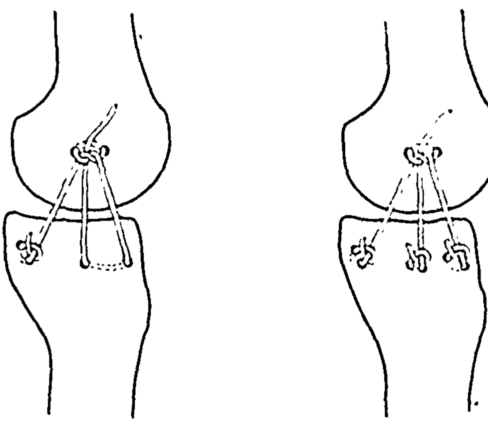

FIG. 1

The authors' method of repair of the medial collateral ligament.

In a case of rupture of both crucial ligaments and the medial collateral ligament of the knee, repair of the medial collateral ligament alone was done by the authors, as shown in Figure 1. It was thought *at the time that repair in this* fashion might obviate the need for reconstruction of the crucial ligaments. This was later found to be the case, apparently due to the fact that the anterior strand of fascia lata limits the forward slipping of the tibia and the posterior strand stops the posterior displacement.

A review of the literature shows numerous methods of repairing the collateral ligament, but rarely is mention made of stabilization of the knee and ruptured crucial ligaments by the repair of the collateral ligaments. Bennett plicated the collateral ligament with fascia lata; Bost, Edwards, and McMurray used nearby tendons; and Wilson turned down a fascial flap. Cotton and Morrison in 1934 advocated a cross-shaped method of repair. (See Figure 2.) Their procedure most nearly approximates the authors' method, which follows:

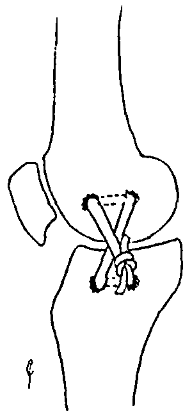

FIG. 2

The cross-shaped method of repair advocated by Cotton and Morrison. (*Reproduced through the courtesy of The New England Journal of Medicine.*)

A full-length exposure of the lateral aspect of the fascia lata is made and a heavy section is removed from the crest of the ilium to the knee joint. This strip is then implanted posteriorly in a tunnel in the tibia and tied, and the knot is sewed with silk. The free end is drawn through a tunnel located at the femoral epicondyle and a knot is tied, as shown in Figure 1. The end

is then passed backward through a tunnel in the anterior part of the tibial condyle to the point of original attachment of the collateral ligament, and thence upward to be tied and sewed with silk to the preceding knot at the femoral epicondyle. In case the external collateral ligament is being repaired, which is a rare condition, the attachment may be to the tibia and the head of the fibula.

A circular plaster splint should be applied from the groin to the ankle. This splint is worn for four weeks, subsequent weight-bearing and physiotherapy being carried out as indicated by the progress of the patient.

This procedure has been used in three recent cases,—two of rupture of the crucial ligaments and medial collateral ligament and one of rupture of the crucial ligament and the external collateral ligament. In all three cases, an attempt was made to repair the collateral ligament as well as to reenforce it with a few fascia-lata strands, but repair of the crucial ligaments was not attempted, as the damage to them was so severe that repair was not possible. In spite of the fact that the crucial ligaments were never repaired, all three knees were satisfactorily stabilized as far as lateral sway and anteroposterior displacement were concerned.

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STABILIZATION OF THE HIP BY THE TRANSPLANTATION OF THE ANTERIOR THIGH MUSCLES

BY LEWIS CLARK WAGNER, M.D., AND PETER CYRUS RIZZO, M.D.,
NEW YORK, N. Y.

From the Hospital for the Ruptured and Crippled

The transplantation of the tensor fasciae femoris, sartorius, and straight head of the rectus femoris is suggested as a new method for stabilizing the hip in paralysis of the gluteus medius associated with weakness of the gluteus maximus, because it seems mechanically and physiologically more efficient than any of the existing operations. The mechanical advantages are: the increased strength of the transplant, the exertion of a diverse directional pull, and the increased support to the knee.

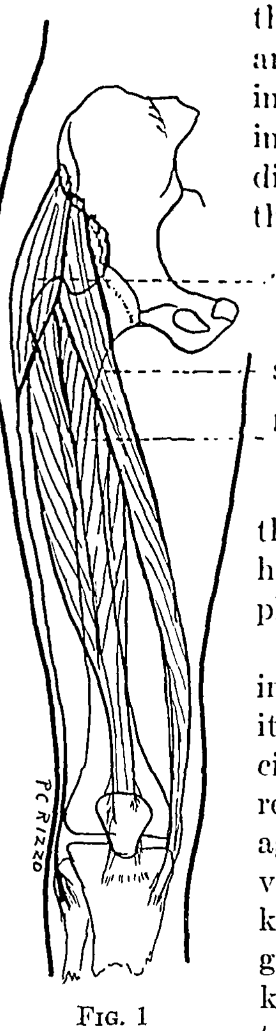

FIG. 1

Drawing demonstrating the origin and insertions of the muscles used as a transplant.

The increased strength of the transplant, in contrast to other procedures, is credited to the use of three good-sized muscles in place of the one muscle commonly employed. When joined, the tensor fasciae femoris, the sartorius, and the long head of the rectus femoris make a formidable transplant.

The diverse directional pull of these muscles is important, as it tends to hold the head of the femur in its proper position more efficiently. The tensor fasciae femoris is in the "line of straight pull". The rectus femoris and sartorius exert their pressure against the upper third of the femur and thereby prevent slipping of the femoral head. The increased knee support is of great consideration. The sartorius gives medial support and prevents "bending in" of the knee. The rectus femoris, by virtue of the quadriceps tendon, forms a strong anterior support, and the tensor fasciae femoris reenforces the knee laterally. Therefore, the combination of these muscles affords a good brace to this joint.

The physiological advantages lie in the contracting power that is invested in this conjoined group of muscles.

OPERATIVE TECHNIQUE

An incision is made, beginning at the posterior-inferior spine and following along the crest of the ilium to the anterior-superior spine. At this point the incision is brought downward and across the trochanter. The tensor fasciae femoris and sartorius are identified and removed from their origin along with some of the bony attachment. These muscles are freed as far as possible by blunt dissection. This procedure exposes the straight head of the rectus femoris, which is also detached and liberated as far as possible. The straight head of the rectus femoris is then sutured to the tensor fasciae femoris and sartorius: in this manner, quite a large mass of muscle is formed.

An area is prepared in the region of the inferior-posterior spine by cutting a small window in the ilium. The location for this window is ascertained by holding the extremity in extreme abduction and hyperextension and thereby determining the reach of the transplanted muscle. A tunnel is then made under the paralyzed gluteus medius and the anterior border of the gluteus maximus, and the transplant is carried through this tunnel while the limb is held in hyperextension and abduction. The conjoined muscles are fixed into the prepared space. After the wound has been closed in layers, a plaster spica is applied with the extremity in the position of hyperextension and abduction. The plaster is removed at the end of four to five weeks.

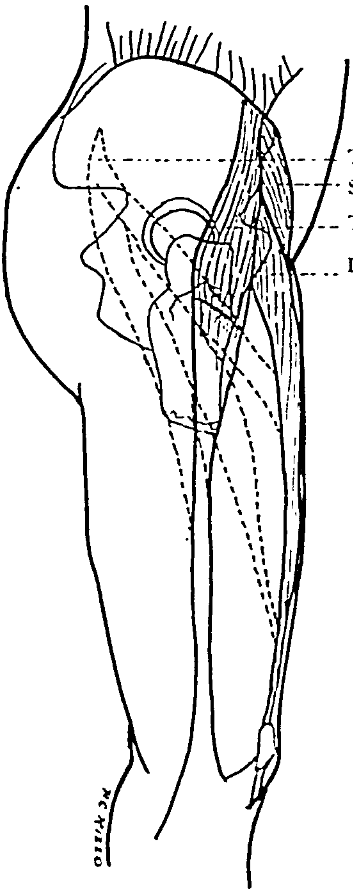

Fig. 2

Lateral view showing the directional change of the muscles used in the transplant.

This operation has been used in five cases with gratifying results. In each case the patient benefited by the operation: the typical gait resulting from gluteal paralysis was completely altered to one of security.

CASE REPORTS

M. H., a female, had had poliomyelitis in 1926. She had full power in the tensor fasciae femoris and partial power in the gluteus maximus. Her gait was peculiar and she walked with a marked limp. On April 21, 1932, the operation described was performed. The postoperative findings show that the buttocks have filled out, the swaying gait has dis-

appeared, and the patient is able to hyperextend the leg and also to abduct it against gravity. There is good external rotation, but internal rotation is not possible.

S. T., a male, had had poliomyelitis at the age of two years. There was slight power in the gluteus medius and the gluteus minimus. Other muscles about the hip were not functioning. A muscle-transplant operation was performed on April 15, 1932. The patient is now able to walk better and to hold the extremity in extension and hyperextension against gravity. The leg feels stronger, is more useful, and more stable.

A. M., a male, had had poliomyelitis at the age of seven and one-half years. There was a paralysis of the glutei and good power in the tensor fasciae femoris. His gait was poor. A transplant operation was performed on June 19, 1932. Both the patient and his family have noted considerable improvement in gait and attitude. There is good power of abduction and external rotation; internal rotation is absent. The patient is able to walk longer distances and to abduct and extend the leg against gravity.

R. W., a female, had had poliomyelitis at sixteen years of age. There was good power in the tensor fasciae femoris and the sartorius. The glutei were paralyzed and the patient was obliged to use a brace for support. A transplant operation was performed in November 1931. Since then, the limp has disappeared and the brace has been discarded. The hip is more stable and the patient is able to abduct and hyperextend the hip.

E. B., a female, had had poliomyelitis at the age of ten years. Normal power was present in the tensor fasciae femoris and the sartorius. The gluteus maximus was very weak and the gluteus medius was paralyzed. There was a marked swaying of the body in walking. A transplant was done November 14, 1934. At the last examination, six months later, the entire limb had developed considerably. The patient can abduct the limb against gravity and there is increased power in the gluteus maximus. Her gait shows remarkable improvement and she is able to discard her cane.

SUMMARY

The ideal case for this operation is the one in which the gluteus medius is paralyzed, the gluteus maximus is weak, and the muscles which comprise the transplant—the tensor fasciae femoris, the sartorius, and the rectus—are functioning normally. When these latter muscles are weak, however, great help is also derived from this operation.

Following the operation, the hip and knee are more stable and the swaying gait, which is very fatiguing and awkward, is lost.

The results obtained in the five cases in our series were gratifying.

DYSCHONDROPLASTIC BOW LEGS

BY DAVID SLOANE, M.D., MARIAN FRAUENTHAL SLOANE, M.D., AND
AARON M. GOLD, M.D., NEW YORK, N. Y.

From the Hospital for Joint Diseases *

Dyschondroplasia[1, 6] is a retardation of the normal transformation of primordial cartilage into growing bone, which results in an irregular ossification at the epiphyseal-metaphyseal junction of the long bones. Ollier[5] coined the term and described the first case in 1899. The condition may involve isolated bones or extremities, or there may be a predominantly unilateral involvement of the extremities. Current usage designates the entire group as "dyschondroplasia" and limits the term "Ollier's disease" to the predominantly unilateral involvement of one side of the body[2, 3].

Within the past three years, we have encountered several cases of an unusual form of genu varum caused by a localized dyschondroplasia which was restricted to the inner half of the region of the upper tibial epiphysis. In two cases, the condition was bilateral; in one, unilateral. The patients were young girls ranging in age from four to seven years. In each case, the outstanding clinical feature was a marked degree of genu varum which became progressively worse as the child grew older. Roentgenograms showed similar changes in all three cases. A specimen for microscopic study was obtained in the second case.

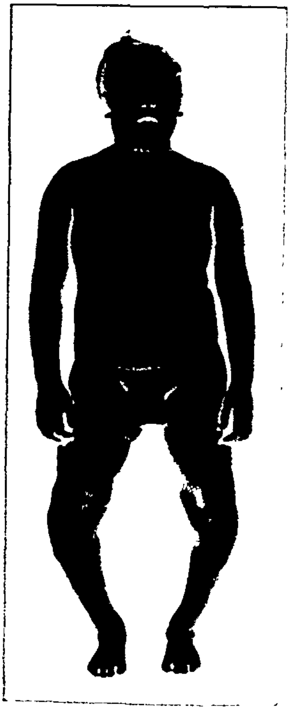

FIG. 1

CASE 1. D. D. Note the acute angle medially beneath the knees.

CASE REPORTS

CASE 1. D. D., a white girl, aged six, was admitted to the Hospital for Joint Diseases in November 1932. According to the mother, the child had developed a bowing deformity of the legs four years previously. This deformity had become progressively worse until it reached the stage shown in Figure 1.

The child's past history was essentially negative. She was born at full term and the delivery was normal. The child had been fed by bottle and had been given viosterol regularly. She began to walk at two years of age. The family history revealed no similar cases of deformity.

Examination showed marked lateral bowing of both legs, with a particularly sharp angulation at the upper

* Orthopaedic Service of Herman C. Frauenthal, M.D.

FIG. 2

Case 1. D. D. Roentgenogram showing the compression, fragmentation, and medial spread of the upper tibial epiphyses and adjacent metaphyses.

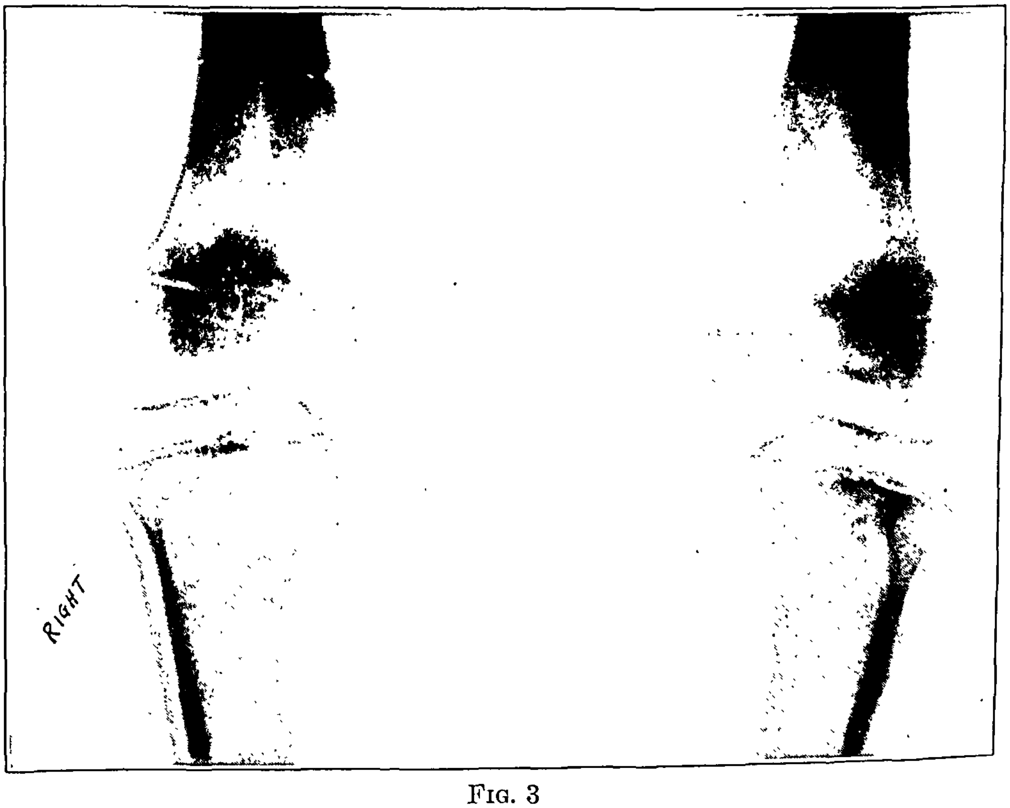

FIG. 3

Case 2. N. C. Note similarity of this roentgenogram to Fig. 2. The condition is less marked here.

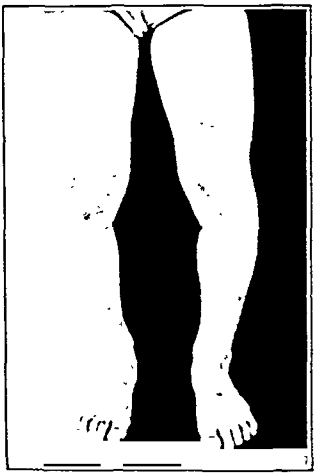

Fig. 4

Case 2. N. C. Note the same acute angulation beneath the knees as shown in Fig. 1.

inner ends of the tibiae. This condition was more pronounced on the right side than on the left. There was secondary bilateral pes valgus. When the patient walked, a marked laxity of the lateral ligaments of the knees made the heads of the fibulae appear prominent.

Roentgenograms (Fig. 2) revealed a sharp compression and fragmentation of the medial aspects of both upper tibial epiphyses. The underlying metaphyses were elongated and mushroomed medially so as to form large, bony masses.

Case 2. N. C., a white girl, aged seven, was admitted to the Hospital for Joint Diseases in October 1934. The mother brought the child to the Hospital because of a bowing of the legs which had begun in infancy and which had become progressively worse. Figure 4 shows the appearance of the limbs upon admission.

The child was born at full term and the delivery was normal. The past history was irrelevant. Two sisters and two brothers were living and well. There was no history of familial diseases.

Examination revealed a marked lateral bowing of both legs, with an acute medial angulation beneath the upper ends of the tibiae. There was slight posterior bowing, with a resultant genu recurvatum. The femora showed some anterolateral bowing. The feet were secondarily pronated because of the lateral bowing.

The roentgenograms (Fig. 3) were similar to those in Case 1, but the condition was less marked. There was the same medial epiphyseal compression and fragmentation, with mushrooming of the metaphyses.

A biopsy specimen was obtained from the medial side of the left epiphyseal plate (Fig. 5). We are indebted to Dr. Henry L. Jaffe and Dr Sheldon A. Jacobson of the Department of Pathology for the following description of the micropathology:

"The line of the epi-

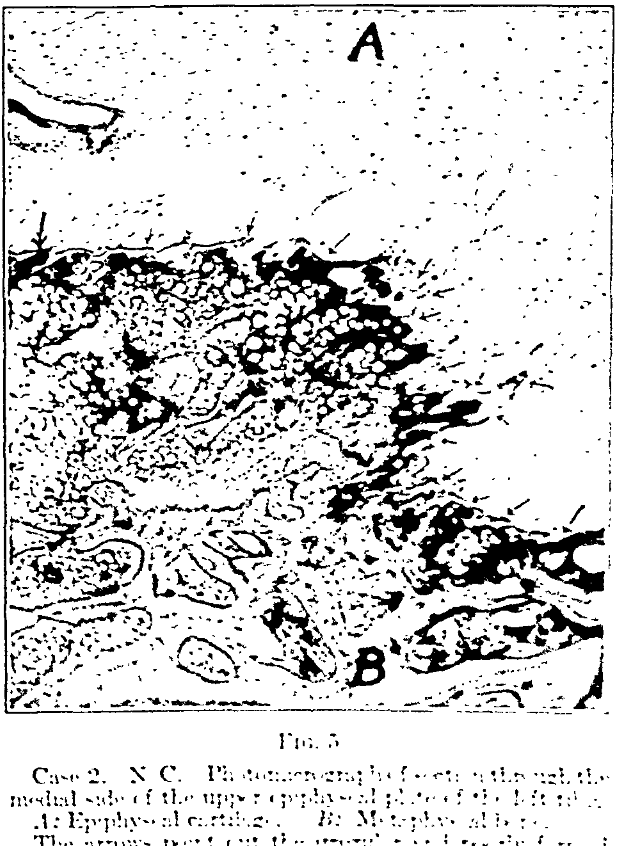

Fig. 5

Case 2. N. C. Photomicrograph of section through the medial side of the upper epiphyseal plate of the left tibia.

A: Epiphyseal cartilage. B: Metaphyseal bone.

The arrows point out the irregular and poorly formed junction between the growing cartilage and the bone.

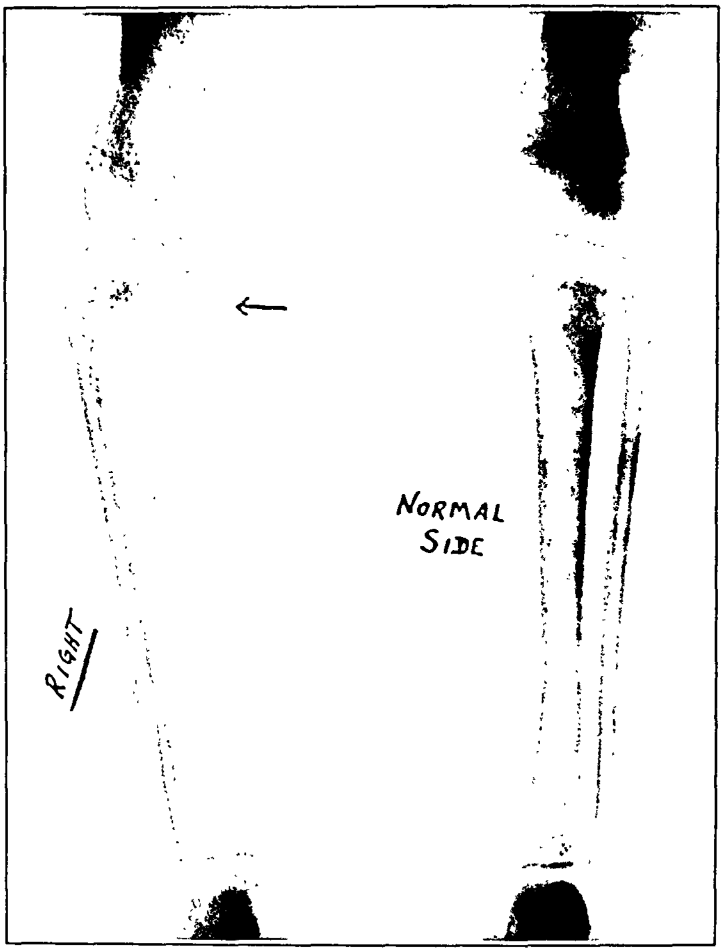

FIG. 6.

Case 3. A. G. Roentgenogram showing definite dyschondroplastic changes on the right side (note the arrow). The left side is normal.

physeal plate slopes sharply downward in the direction of the shaft. The epiphyseal cartilage in this region is rather pale-staining, particularly the nuclei. One gains the impression that the cells are either dead or dying. [This was cell death due to an acute inflammatory lesion which has no bearing on the dyschondroplasia.] They are somewhat more numerous and deep-staining in the part of the area adjacent to the bone. Nowhere, however, does the cartilage even remotely approach the normal epiphyseal architecture. There has been an extremely feeble attempt to group and line up some of the scattered nuclei. However, there is not even a suggestion of the well defined zone of clear cells that characterizes the normal epiphyseal plate, although a few of these clear cells may be seen. The reciprocal alignment of resorbing cartilage and growing bone trabeculae is also absent. In its place there is a very thin, irregularly demarcated zone of poorly calcified cartilage which penetrates in a most uneven fashion into a disorderly arrangement of shapeless bone trabeculae. Many, if not most, of the lacunae in this bone are devoid of nuclei. The marrow spaces show considerable fibrosis. The rows of active osteoblasts are not to be seen.

"Briefly, we have here a condition characterized by a failure of growth, differentiation, and ossification of cartilage cells. Even the 'resting' cartilage appears to be afflicted with a severe trophic disorder. We may interpret the above as a disorder of the dyschondroplastic group."

CASE 3. A. G., a white girl, aged four, was admitted to the Out-Patient Department of the Hospital for Joint Diseases in March 1935, with a history of increasing bowing of the right leg since birth. There were no similar cases in the family. Hospitalization for further study was refused. Examination showed a marked genu varum of the right leg, with a prominence along the inner side of the right knee. There was no limitation of knee motion.

Roentgenograms (Fig. 6) revealed medial compression, fragmentation, and mushrooming of the right upper tibial epiphysis and diaphysis. The left tibia was normal.

The cases cited naturally lead us to a consideration of the pathogenesis of the dyschondroplasias as a group. Murk Jansen[4] wrote an ex-

cellent treatise in which he considered normal bone development as the product of several interrelated processes. Any disturbance of this normal mechanism he termed "a dissociation of bone growth". The condition found in our cases may be considered as a localized form of bone dissociation, characterized by a retardation of the normal sequence of cartilage and bone development in the region of the upper tibial epiphysis.

SUMMARY

Dyschondroplasia is a retardation of the normal transformation of primordial cartilage into bone. In the three cases of dyschondroplastic bow legs presented, the process was limited to the region of the medial aspect of the upper tibial epiphysis. All of the patients were young girls in the first decade of life. In two of the cases, the condition was bilateral; in one, unilateral. A progressive and severe type of genu varum was the outstanding symptom. The roentgenograms showed typical changes in the region of the medial half of the upper tibial epiphysis. Microscopic section in the involved region of one of the patients showed a definite picture of dyschondroplasia.

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CONGENITAL ABSENCE OF THE MEDIAL SESAMOID BONE OF THE GREAT TOE

Report of Two Cases

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From The New York Orthopaedic Dispensary and Hospital

In all standard text-books of anatomy, and in the classical monographs of Pfitzner and Dwight, the two sesamoid bones at the metatarsophalangeal joint of the great toe are described as constant. In a recent extensive survey of the literature, the writer found reported no instance of the congenital absence of either of these sesamoid bones. Since the publication of that survey in 1933, only one paper dealing with the anatomy of the sesamoids has been published, and in this paper the invariable constancy of both sesamoid bones of the great toe is again affirmed.

Within the past year at the New York Orthopaedic Dispensary and Hospital, roentgenograms have been made of the feet of two patients showing congenital absence of the medial sesamoid bone. These patients were adults, one male and the other female, and neither came to the Dis-

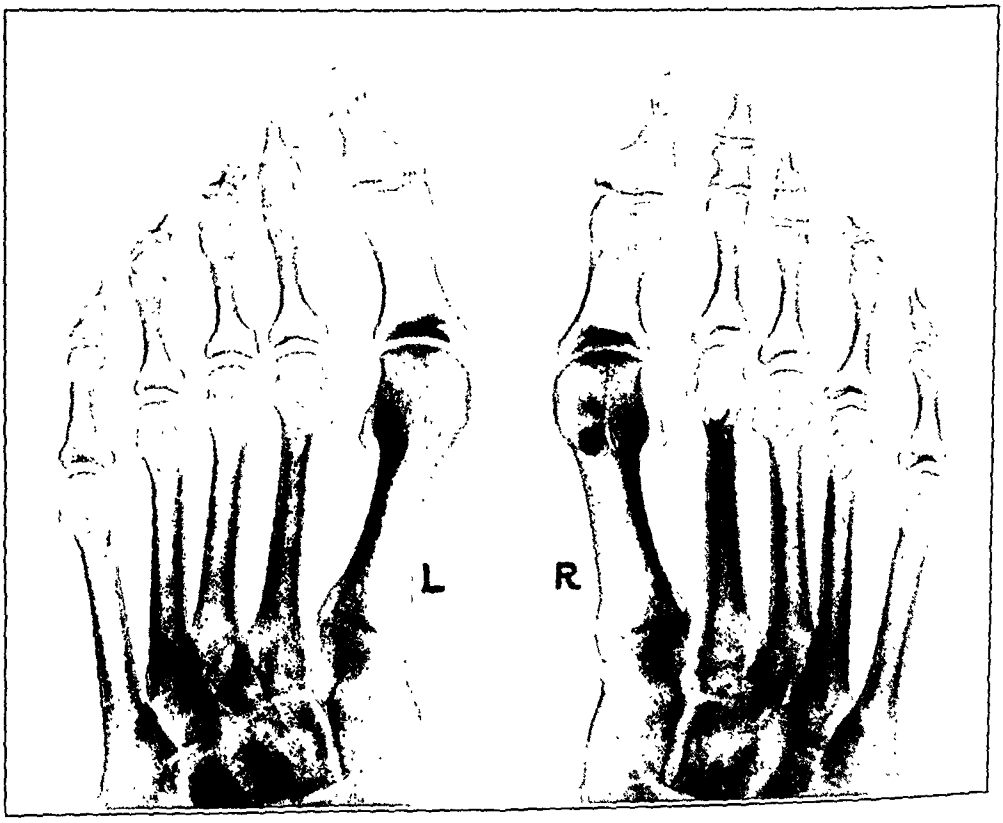

Fig. 1

Case No. 158,306. G. S., aged twenty-eight. Left medial sesamoid absent; right medial sesamoid small and bipartite. No symptoms referable to sesamoids.

pensary complaining of symptoms referable to the region of the sesamoid bones. Upon careful inquiry, it was ascertained that neither had ever had any complaint referable to these bones, and their claim that no opera-

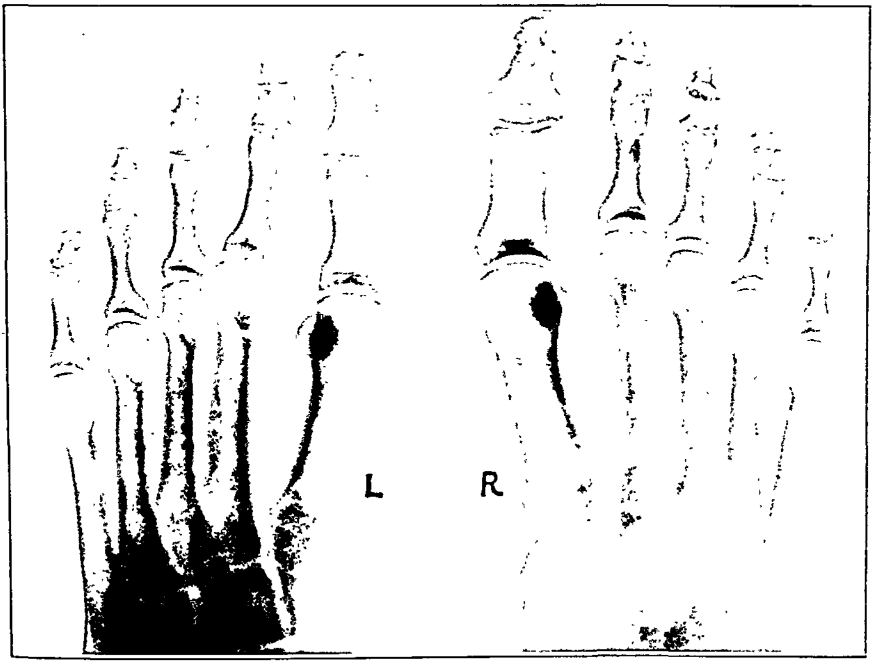

FIG. 2.

Case No. 181,922. J. C., aged thirty-three. Left medial sesamoid absent; right medial sesamoid rudimentary. No symptoms.

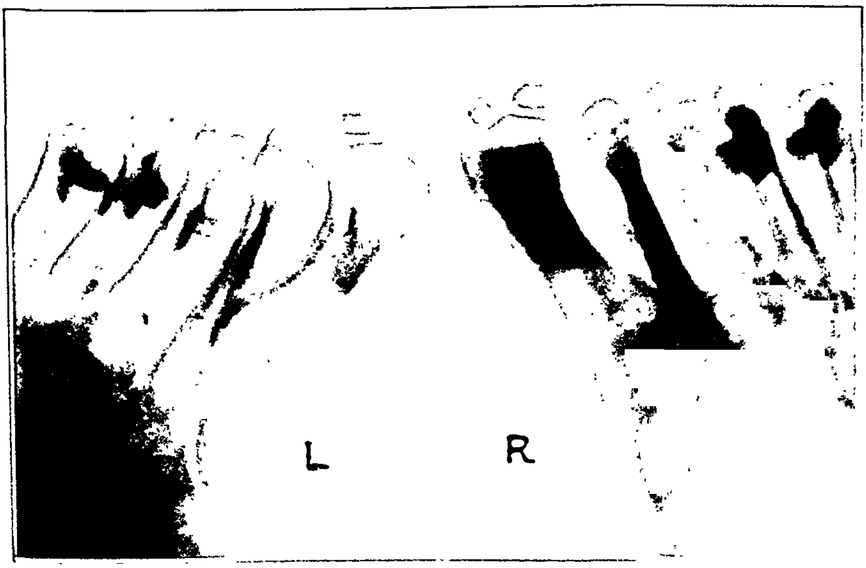

FIG. 3.

Plantar view of feet of patient shown in Fig. 2.

FIG. 4
Plantar view of feet of patient shown in Fig. 2.

tion had ever been performed on the foot was substantiated by the absence of any surgical scar. In each patient, the left medial sesamoid was absent. Physical examination demonstrated no abnormal physical signs. There were no disturbances of the function of the great toe, nor of the posture or function of the foot as a whole, resulting from this anomaly.

Figures 1 and 2 show the anteroposterior roentgenograms of the feet of these patients and Figures 3 and 4, the plantar views. It is interesting to note that the medial sesamoid of the opposite foot in each case is of diminutive size.

Neither of these patients has children, and the parents of both are unavailable for roentgenographic study.

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FRACTURES AND DISLOCATIONS ABOUT THE SHOULDER *

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In reviewing the group of sixty-four fractures and dislocations about the shoulder, which have been treated at the University of Virginia Hospital during the past three years, and in correlating the methods of treatment and the results, one becomes more and more impressed with the conclusions of such masters as Sir Robert Jones that each separate problem presented in these fractures must be faced individually and that no one set of rules in regard to routine treatment can possibly apply. In one of his last articles, Sir Robert made a plea for the conservative treatment of fractures about the shoulder and, in speaking of fractures with dislocation, stated: "It is unscientific to suggest any routine method of reduction of the loose head". His treatment of all the fractures in this region was seasoned with the simplicity for which he was always noted. He had an inherent objection to the aeroplane splint.

Roberts, in his masterful article on fractures of the upper end of the humerus, emphasizes what we consider to be one of the most important adjuncts in the treatment of these fractures,—the taking of axillary-view roentgenograms to determine the anterior-posterior displacement of the fragments in order that the problem of reduction may be more clearly visualized. The taking of such views has been our rule for many years in treating all fractures about the shoulder. In the treatment of other fractures, we are not satisfied to depend on the appearance of the fragments in an anterior view only or in stereoscopic plates, and we cannot get a true conception of the clinical picture presented by fractures and dislocations about the shoulder without the knowledge derived from the lateral view.

Howard and Eloesser, in 1934, demonstrated very vividly in their phantom model, by means of rubber-band muscles attached to the bones composing the shoulder girdle, many of the mechanisms involved in fractures and in the reduction of fractures. But, unfortunately, such a model does not reproduce the reflex spasm and relaxation of the involved muscles. We are aware of such actions in the human, although it may be overcome to some extent by anaesthesia. These authors, however, like Sir Robert Jones, Roberts, Böhler, and Key and Conwell, have joined in sounding the death knell to the routine of complete abduction in plaster or splints.

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 7, 1935.

The conventional method of classifying fractures in the region of the shoulder has been as follows:

1. Separation of the upper humeral epiphysis;
2. Fracture of the anatomical neck;
3. Fracture of the surgical neck;
4. Separation and fracture of the tuberosities;
5. Fractures in the region of the glenoid;
6. Fractures of the acromion process and those involving the acromioclavicular joint;
7. Fractures associated with dislocation of the head of the humerus.

There have been numerous attempts by some authors, such as Kocher, and Howard and Eloesser, to make changes in the nomenclature which would more accurately describe these fractures, but so far such changes have not been generally accepted.

Probably the most difficult of all the fractures about the shoulder joint to reduce is a fracture of the humerus complicated by a dislocation of the head. Removal of the head has been advocated and resorted to by many surgeons (Trottier, Chalier). Such treatment should be reserved for cases which have been untreated for a number of weeks. It is not necessary to perform an open reduction in fractures of the tuberosities and of the neck as often as might be thought from the statements of Greeley and Magnuson, Frey, Sabadini, Chalier, and de Bernardi. However, in a few cases such a procedure is unavoidable.

Whenever possible, we have attempted to simplify the treatment of fractures of the shoulder by making use of the weight of the dependent arm in a swathe and neck-wrist strap to secure adequate protection over a short period of time with very early motion. During the earlier part of the three-year period from which the statistics contained in this paper were taken, many of the patients were treated with casts in abduction; whereas, later on, the Velpeau bandage or swathe was more frequently used. We are able, therefore, to make some comparison between the two methods of treatment.

One almost constant finding brought to our attention by the axillary-view roentgenograms is the anterior buckling of the fragments at the point of fracture, due to the spasm of the pectoral muscles. This buckling of the fragments must be corrected, so that the humerus, when healed, will rotate on its longitudinal axis.

The outstanding difference in our comparison of the two methods of treatment is in the condition of the muscles and joints at the end of the time of protective treatment. In cases where the cast was used, prolonged after-treatment was necessary. In the cases treated by the other method, free motion was usually present by the time of healing of the fracture.

In most of our cases of fractures of the neck and of the tuberosities, sufficient healing of the bone had taken place in about two weeks to allow motion and to prevent distortion from muscle pull. By conventional exercises such as swinging a two or three-pound weight,—first standing,

TABLE I

CASES OF FRACTURE OF THE NECK OF THE HUMERUS TREATED BY VELPEAU BANDAGE AND NECK-WRIST STRAP

Age Group (*Years*)	No. of Cases	Average Time in Velpeau Bandage (*Days*)	Average Time of Physiotherapy, Sling, and Strap (*Days*)	Average Time of Treatment (*Days*)
10–20	5	21	21	42
20–30	2	14	28	42
30–50	2	14	28	42
60–85	3	16	26	42

then bending gradually forward, then swinging laterally across the front of the body—muscle power and free motion in the joints have been restored at a very early stage.

The sixty-four cases of injury about the shoulder upon which this paper is based included forty-eight fractures, eleven uncomplicated dislocations of the shoulder, and five uncomplicated dislocations of the acromioclavicular joint.

UNCOMPLICATED FRACTURES OF THE NECK OF THE HUMERUS

There were twenty-seven cases of fracture of the neck of the humerus. From the standpoint of age, these occurred as follows:

Age Group	*Cases*
0– 5 years	1
5–10 years	1
10–15 years	8
15–20 years	2
20–30 years	5
30–50 years	4
50–60 years	1
60–85 years	5
Total	27

In this series, there were fourteen males and thirteen females; twenty-four were white and three were colored.

Of these twenty-seven patients, twelve were treated by means of a Velpeau dressing, with the arm against the side for an average period of nineteen days. This was followed by a neck-wrist strap for an average period of two weeks. (See Table I.)

Fifteen patients with fracture of the neck of the humerus were treated by casts with the arm in abduction for an average period of thirty days, followed by a sling for a period of two weeks,—a total of forty-four days of treatment before the return of function. (See Table II.)

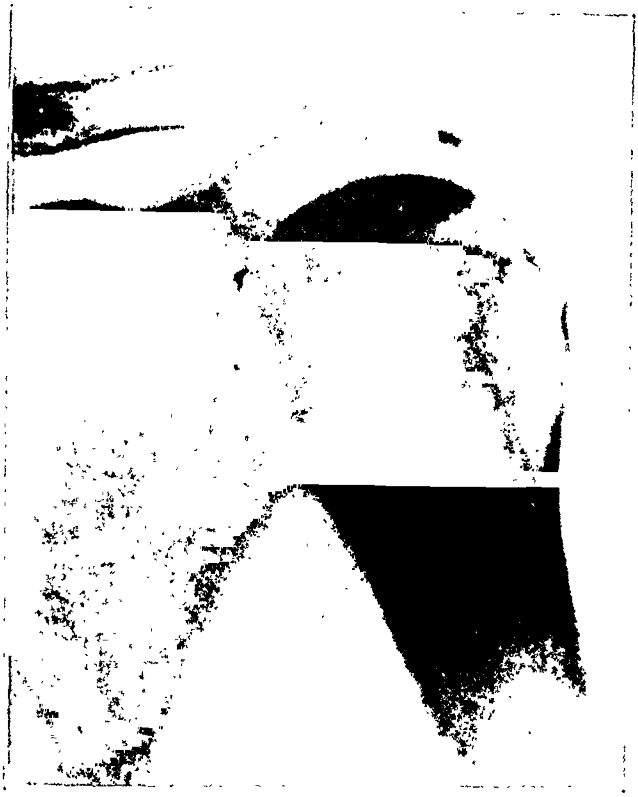

Fig. 1

Anterior view of acromion, showing little evidence of injury.

FRACTURE OF THE NECK OF THE HUMERUS WITH DISLOCATION OF THE HEAD

In four cases, there was a fracture of the humeral neck and a dislocation of the head of the humerus. One of these patients was treated by closed reduction with a Velpeau bandage, followed by complete return of motion and function in ten weeks. In the second case, closed reduction was unsuccessful and open reduction was done ten days after the injury. The third patient refused treatment, and the fourth was treated by resection of the head ten weeks after attempted open reduction. The result in this last case was interesting in that there was return of motion of 60 per cent., and the patient was able to return to employment in a post office.

Fig. 2

Oblique view of shoulder shown in Fig. 1, revealing a complete fracture of the acromion process.

FIG. 3
Anteroposterior view, showing little evidence of injury.

DISLOCATION OF THE HEAD OF THE HUMERUS

There were twenty-three cases of acute dislocation of the humerus: seventeen males and six females. Seventeen were white and six were colored.

Simple dislocation, unassociated with fracture, was found in eleven cases. Five of these dislocations occurred in the right arm and six in the left. All were subglenoid and anterior.

In the other twelve cases, the dislocation was associated with fracture, as follows: fracture of the greater tuberosity, six cases; fracture of the neck of the humerus, four cases; fracture of the greater tuberosity and of the acromion process, one case; and fracture of the greater tuberosity and of the coracoid process, one case.

TABLE II

CASES OF FRACTURE OF THE NECK OF THE HUMERUS TREATED BY SHOULDER SPICA

Age Group (*Years*)	No. of Cases	Average Time in Cast (*Days*)	Average Time of Physiotherapy and Sling (*Days*)	Average Time of Treatment (*Days*)
0–5	1	28	14	42
5–10	1	24	16	40
10–20	5	32	15	47
20–30	3	33	11	44
30–50	2	35	7	42
50–60	1	28	14	42
60–85	1 *	28	14	42

* One other patient, aged eighty-one, died five days after leaving the hospital.

There were four recurrent dislocations which were treated by the Nicola operation, and one chronic dislocation, treated by open reduction and the Nicola operation six weeks after the dislocation had occurred.

The distribution of the dislocations according to age was as follows:

Age Group	*Cases*
0–15 years	0
15–20 years	3
20–30 years	4
30–40 years	2
40–50 years	7
50–60 years	3
60–85 years	4
Total	23

In the case of a simple dislocation, the average time of treatment before recovery of function was twenty-one days; in that of a complicated dislocation, forty-four days.

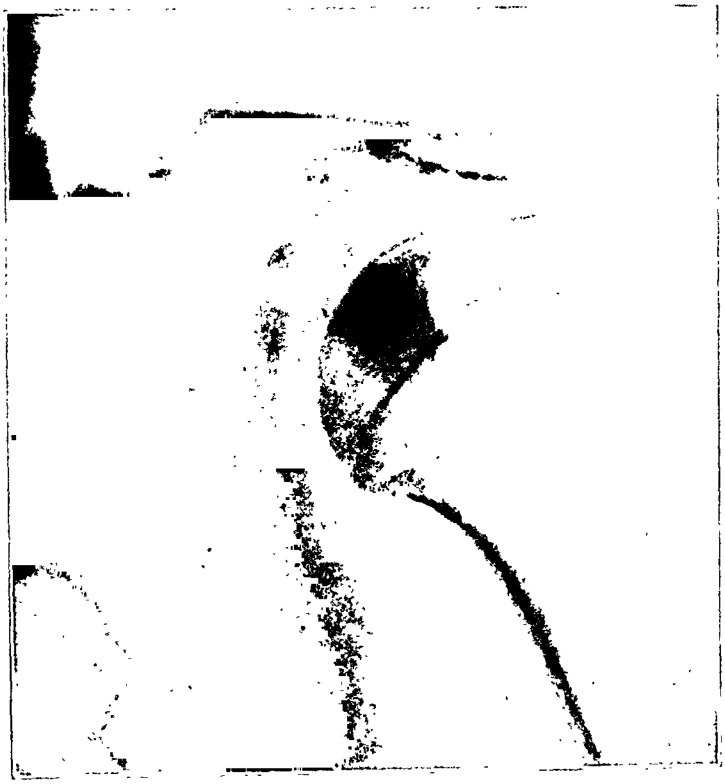

FIG. 4

Oblique view, showing fracture of tuberosity.

It seems very important that minute fractures in the region of the tuberosity be given the utmost consideration, for this type of injury may entail even more serious consequences than when larger chips of bone are detached. It is in this type of injury that we so often find a prolonged period of disability resulting from lack of thoroughness because of the apparent insignificance of the injury. The majority of these small fractures will heal without complication if given time, but, in two of our cases, it was necessary to repair the supraspinatus tendon. The clinical significance of this type has been brought out by Codman, Speed, Magnuson, and others.

ACROMIOCLAVICULAR DISLOCATION

There were five cases of acromioclavicular dislocation, including one associated with fracture of the outer third of the clavicle. All of these cases were treated by a primary Velpeau dressing with adhesive and pad strapping for an average period of two weeks, followed by a figure-of-8 bias-bandage dressing for a period of four weeks. In all cases, during the

period of observation, there was complete return of function without recurrence of dislocation.

It is unfortunate that x-rays taken in any one plane cannot be depended upon for a diagnosis of acromioclavicular dislocation. It is necessary that the diagnosis be made either clinically or by holding the shoulder girdle in a position which will maintain the dislocation while the x-ray is being taken.

FIG. 5

Typical oblique view of fracture near shoulder, showing type of displacement.

COMPLETE TRANSVERSE FRACTURE OF THE ACROMION PROCESS

Of particular interest were two cases of complete transverse fracture of the acromion process in which the diagnosis was made by the axillary-view roentgenograms combined with the history and clinical findings. These fractures could not be demonstrated by the anterior-posterior or stereoscopic x-rays. In each case treatment was by the Velpeau bandage and sling. Early motion with complete recovery resulted in the first case. The second patient is still under treatment. The condition, described by Köhler as delayed union of the acromial epiphysis, should not be confused with this type of fracture.

SUMMARY AND CONCLUSIONS

1. From the information and experience derived from the reduction, fixation, and after-care of sixty-four cases of injury about the shoulder joint, including fractures and dislocations, conservative treatment is urged.

2. Axillary-view roentgenograms are helpful in more clearly understanding the problem involved in reduction.

3. After reduction, the treatment of fractures and dislocations of the shoulder by casts or splints with the arm in the abducted position is unnecessary in most cases and contra-indicated in many.

4. X-rays taken from any one angle should not be relied upon for the diagnosis of acromioclavicular dislocations.

5. After reduction, the primary use of the Velpeau bandage or swathe with the elbow well across the chest, followed by a neck-wrist

strap and early exercises, tends to promote the maximum recovery of motion and function in the shoulder joint in the shortest time.

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OLD TRAUMATIC DISPLACEMENT OF THE DISTAL FEMORAL EPIPHYSIS

Successful Open Reduction Followed by Epiphyseal Arrest of the Normal Femur

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Complete traumatic epiphyseal separation in the lower end of the femur, with anterior displacement—so called "cart-wheel fracture"—is not as common today as it was during the horse-and-wagon age. Several decades ago, such injuries occurred more frequently and were due to the engagement of the leg between the spokes of a moving wheel. The leverage force usually causes the diaphysis to slip backward into the popliteal space, as the epiphysis slips anteriorly in front of the shaft of the femur, with its separated surface in contact with the lower end of the shaft. Because of the firm attachment of the periosteum at the epiphyseal line, there is considerable stripping of the periosteum. This is important in the consideration of the repair of such fractures. It is reported [1, 2, 4, 5] that the posteriorly displaced shaft may cause pressure upon the vessels and nerves. Gangrene of the limb from injury to the vessels, or sloughing of the skin from pressure, may occur. If the fracture is compound, suppuration may result. Paralysis, due to injury to the nerve, may complicate this fracture.

The diagnosis of a recent displacement is made from the history of a violent injury (usually occurring in a boy from nine to fourteen years of age) and the appearance of marked swelling at the knee joint, with shortening of the extremity and preternatural mobility. Circulatory or nerve disturbance may be present.

The treatment consists of immediate gentle reduction by manipulation under anaesthesia. This may be accomplished by flexion of the knee and the exertion of traction in two planes,—that is, in the axis of the femur and in the axis of the leg. Pressure of both thumbs above the condyles of the femur, while the traction is being exerted, will aid in the reduction. The knee is flexed to a right angle and a plaster-of-Paris cast is applied. This cast is worn for two weeks. At the end of this period, the knee is flexed to 135 degrees and another cast is applied. This, in turn, is removed at the end of two weeks. The knee is then brought to 180 degrees and a third cast is applied. This cast is worn for one to two weeks.

The treatment of an old unreduced separation of the distal femoral epiphysis presents a more complicated problem, as shown by the following case.

W. D., a boy, aged thirteen, was admitted from the Out-Patient Clinic to the [illegible] Service at Cook County Hospital, May 18, 19[illegible], with a [illegible]

back of the left knee by a horse seven weeks prior to admission. Roentgenograms, made at a small country hospital near the scene of the accident, had been reported "negative", but a plaster-of-Paris cast had been applied. This cast had been worn for several weeks.

The complaint on admission was limitation of flexion of the left knee to 160 degrees and shortness of the left lower extremity of approximately one and one-half inches. The patient walked with a marked limp.

Fig. 1-A

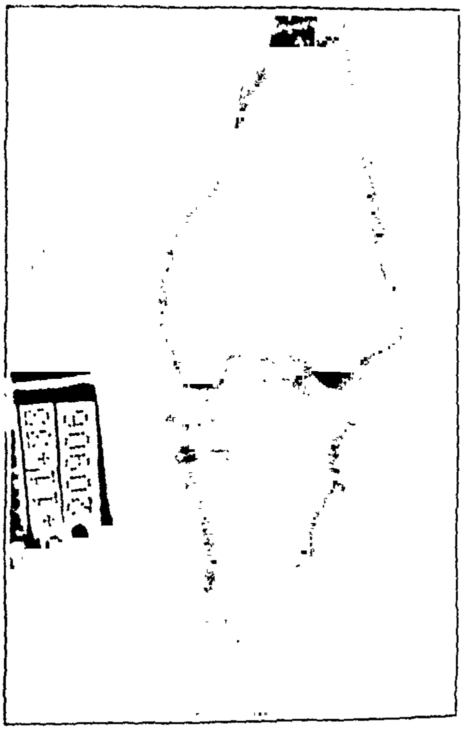

Fig. 1-B

Roentgenograms showing displacement of the distal epiphysis of the left femur, with firm bony union.

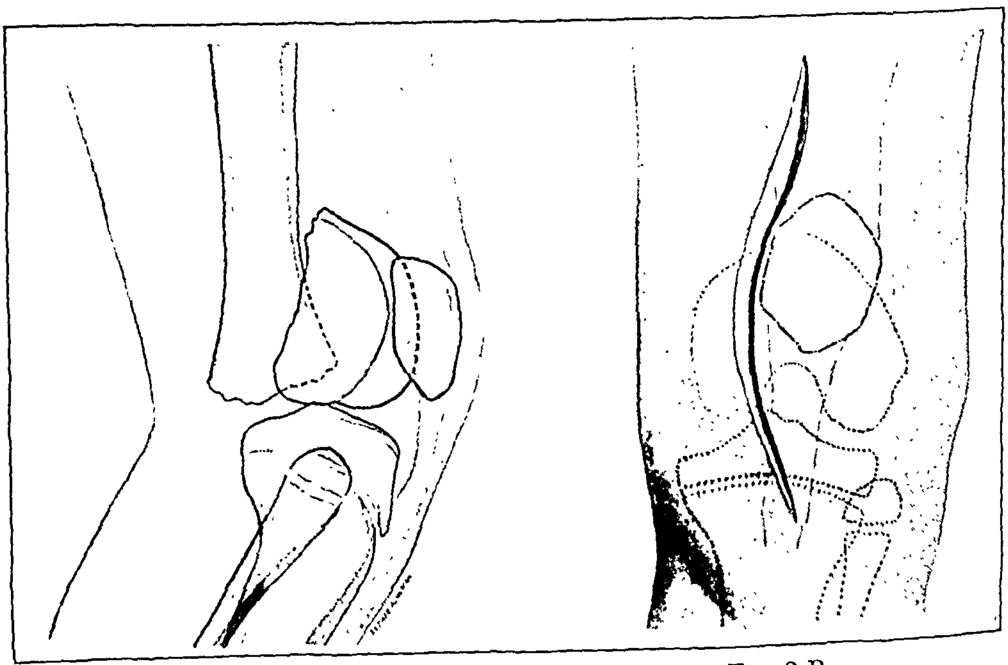

Fig. 2-A

Drawing of Fig. 1-A, showing the pathology.

Fig. 2-B

Drawing of Fig. 1-B, showing the line of incision.

Fig. 3-A

Tenotomy of the quadriceps by the Z-plastic operation. The condyles are separated from the anterior aspect of the shaft. Then, while the knee joint is flexed, the author's bone skid is used to replace the epiphysis.

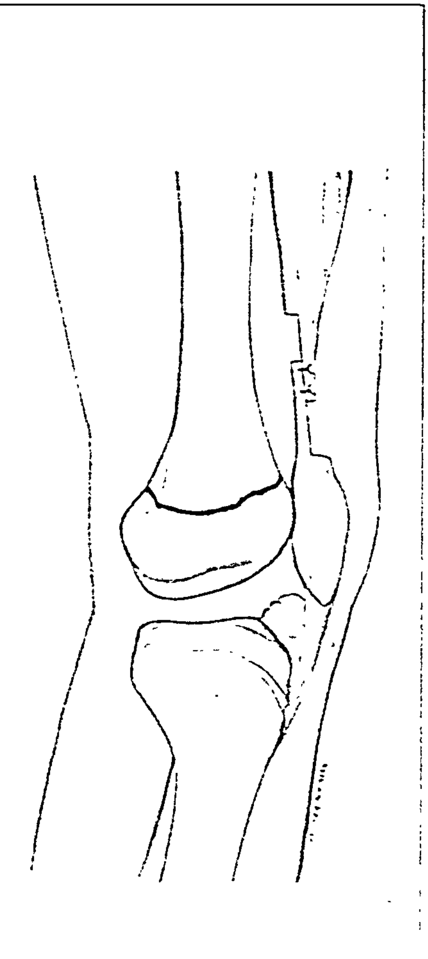

Fig. 3-B

Showing the repair of the quadriceps with lengthening of the fragments and restoration of their normal apposition.

Roentgenograms (Figs. 1-A and 1-B showed a complete anterior displacement of the distal femoral epiphysis, the distal end of the diaphysis resting upon the articular surface of the tibia. Considerable callus was shown beneath the raised periosteum, particularly on the medial border of the shaft of the femur.

Under ether anaesthesia, and with tourniquet hemostasis, a long anteromedial incision was made in the lower third of the thigh and knee joint. The quadriceps tendon was incised by the Z-plastic operation on the flat surface, exposing the femoral condyles which were found firmly attached to the anterior surface of the lower end of the diaphysis (Fig. 2-A). The epiphysis was separated by chisel and mallet. By means of the author's bone skid and simultaneous gradual flexion of the knee, the epiphysis was replaced distal to the diaphysis (Figs. 3-A and 3-B).

A plaster-of-Paris cast was applied for six weeks, followed by the institution of physical therapy. A wedge cast was then applied to correct flexion contracture.

Eight months after the first operation, the range of motion was 180 to [illegible] degrees,

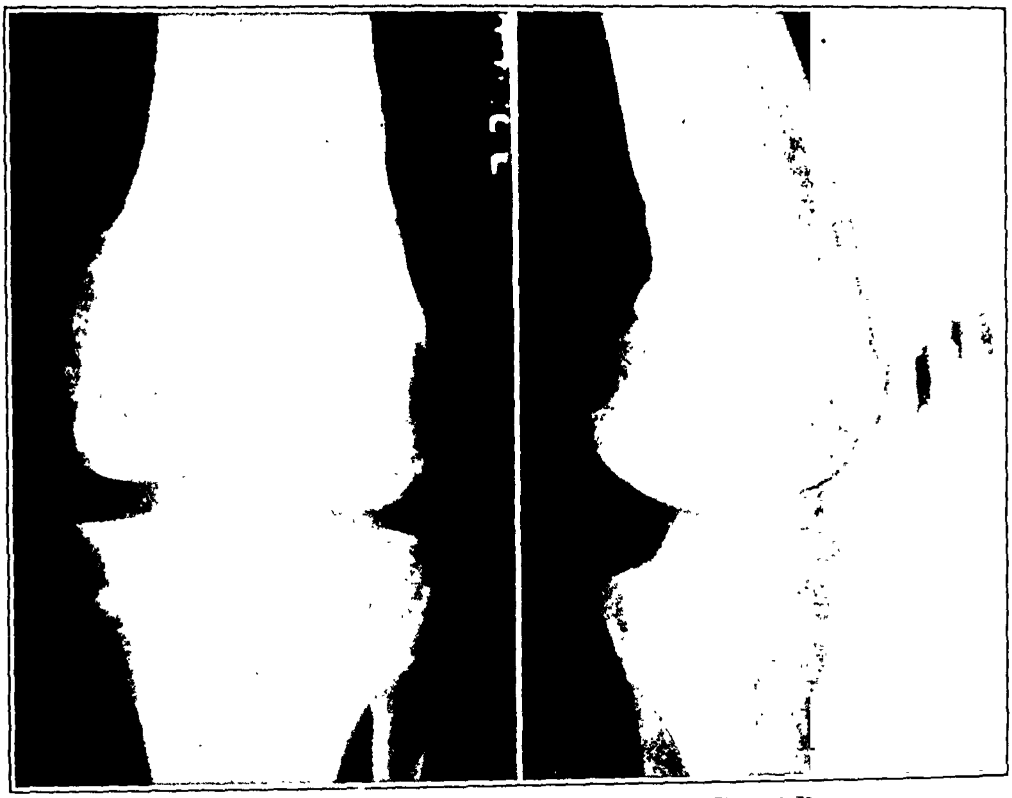

FIG. 4-A FIG. 4-B

Anteroposterior and lateral views of the left femur, eight months after open reduction.

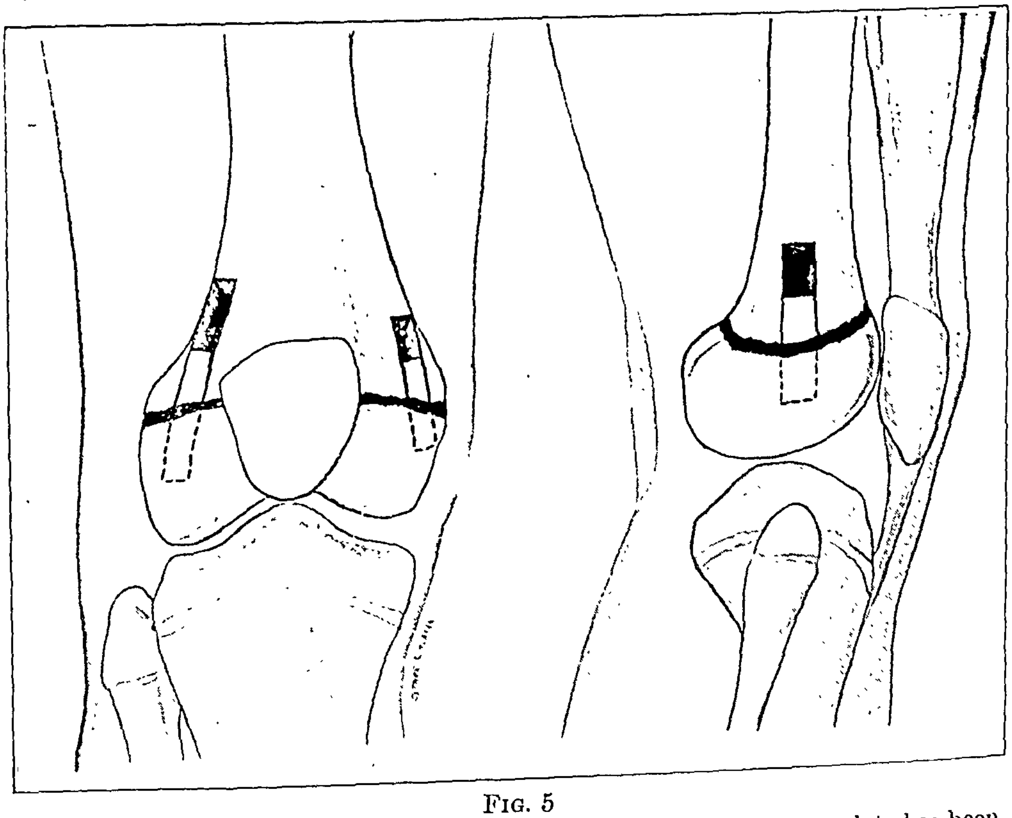

FIG. 5

Sketches representing method of epiphyseal arrest. The cartilage plate has been thoroughly curetted and packed with small bone grafts. Two larger grafts from the diaphysis are *driven into* the epiphyseal condyles half-way across the epiphyseal line.

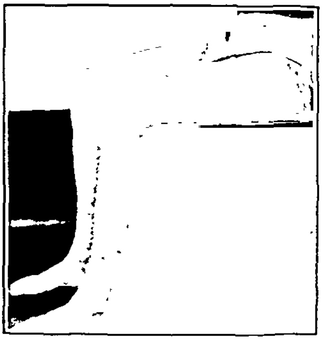

FIG. 6-A

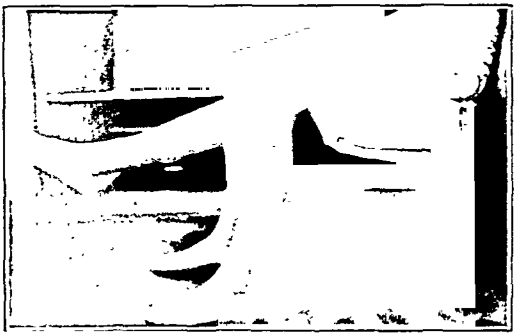

FIG. 6-B

About eleven months after epiphyseal arrest. Photographs showing the contour and range of motion of the injured (left) leg, as compared with its mate. The right knee has a normal range of motion and the left has a range from 180 to 100 degrees.

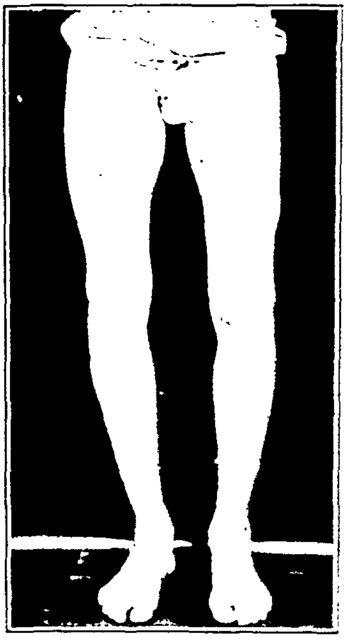

FIG. 6-C

and the roentgenograms (Figs. 4-A and 4-B) showed a normal relation of the fragments, with fusion of the epiphyseal line. It was immediately decided to do an epiphyseal arrestment[3] of the normal (right) side, to which the mother of the patient objected. However, fourteen months after the first operation, when there was one-half an inch of shortness, the mother finally consented to arrestment of growth of the lower femoral epiphysis of the normal side.

The patient was readmitted to the Hospital on July 14, 1934, and was operated upon on July 18, 1934. Under ether anaesthesia, and with tourniquet hemostasis, medial and lateral incisions, two and one-half inches long, were made over the condyles of the right femur. The epiphyseal line was exposed and the cartilage plate was thoroughly curetted. A number of small grafts were placed between the epiphysis and the diaphysis. Small sliding bone grafts from the diaphysis, one inch by three-eighths of an inch, were placed across the epiphyseal line medially and laterally (Fig. 5). A cast was applied from the groin to the toes.

The patient was discharged from the Hospital on July 31, 1934. The cast was worn for six weeks and then physical therapy was started, together with active use. Complete motion was regained in three weeks. Roentgenograms, made three months after the operation, revealed definite closure of the epiphyseal line. Figures 6-A, 6-B, and 6-C show the present contour and range of motion of the knees. The boy walks without a limp and participates in major sports.

Scudder has reported a similar case in a boy seven years of age, in which the displacement was reduced by open operation.

CONCLUSIONS

This case is of interest for several reasons:

1. It presents a rather unusual injury, with the distal femoral epiphysis displaced and united anteriorly to the metaphysis.

2. Although shortness of the extremity of one and one-half inches was present, it was possible to secure by operation an anatomical reduction with restoration of normal length.

3. The equality of the extremities was maintained by arresting the growth of the opposite distal femoral epiphyseal plate.

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SUPRATROCHANTERIC CALCIFICATION

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Calcified deposits in the region of the greater trochanter are potential causes of pain and disability referable to the hip. In a review of the roentgenograms of 650 hip joints, it was found that 100 were of patients less than fifteen years of age and that 550 were of patients between the ages of fifteen and sixty-nine. In the first age group, there was no roentgenographic evidence of calcified deposits about the region of the greater trochanter. In the second group, such deposits were observed in thirty cases, or 5.4 per cent. Therefore, while unusual, this syndrome is by no means rare. At the time of the first consultation, the average age of this group of thirty patients was forty-five years.

In an effort to determine the etiology and outcome of these thirty cases, the records of the Out-Patient Department were investigated. In only twenty-five cases were the records sufficiently complete to warrant inclusion in this study. Of these twenty-five patients, 64 per cent. gave a history of trauma; 24 per cent. presented foci of infection: and 12 per cent. showed evidence of osteo-arthritis elsewhere. The predominant limitations of motion were abduction and internal rotation, due to reflex spasm of the gluteus medius. An analysis of the roentgenograms showed that the calcified deposits varied in size from that of a small pea to the mass described in Case 1.

Roentgenographic and anatomical evidence seems to indicate that there are three different locations for calcified deposits in the region of the greater trochanter:

1. In the tendon of the gluteus medius. (See Case 3.)
2. In the bursa between the tendon of the gluteus medius and the greater trochanter. (See Case 2.)
3. On the under surface of the gluteus medius and not connected with the trochanter. (See Case 1.)

In the region of the greater trochanter, three separate and distinct bursae are present:

1. *Gluteus Maximus:* The most constant and important bursa of the gluteus maximus lies between this muscle and the tendon of the gluteus medius. This bursa is large in size and is generally multilocular.
2. *Gluteus Medius:* A constant bursa lies between the tendon of this muscle and the greater trochanter.
3. *Gluteus Minimus:* A small inconstant bursa lies between this muscle and the greater trochanter.

* Orthopaedic Service of Samuel Kleinberg, M.D.

Of the thirty positive roentgenograms, twenty showed the deposits to be in the tendon of the gluteus medius; eight, in the bursa between the tendon of the gluteus medius and the greater trochanter; and two, on the under surface of the gluteus medius and not connected with the trochanter.

One possible etiological source may be an osteophyte, such as is shown in Case 4, which by its presence may stimulate degenerative changes, resulting in calcification in the muscle or tendon.

It is possible that trauma about the hip joint may be of sufficient intensity to avulse a portion of the trochanter. However, since the tendon of the gluteus medius is almost without blood supply and since the average age of our group of patients is forty-five years, it is more likely that a partial tear of the tendon occurs. The partially torn tendon will then undergo a local necrosis, and, as is usual, these areas will become foci for calcification. Calcified deposits are associated with inflammatory changes in the neighboring tissues, resulting in a swelling of the walls of the tendons and bursae, so that motions which approximate the greater trochanter and acetabulum will cause pain, and this phenomenon corresponds to the clinical picture.

DISCUSSION

It is evident that the pathogenesis of this syndrome is analogous to the syndrome which occurs in the supraspinatus muscle at the shoulder joint.

In the discussion of calcification about the shoulder, Brickner states that, "as a result of contusion or tear of the tendon, there is formation of granulation tissue, necrosis of the tendon substance, and a deposition of lime". Codman believes that rupture in the case of the supraspinatus tendon "occurs in the great majority of cases in aged tendons made weak by overuse, age, or toxic conditions". Stieda described a somewhat similar condition in the ligaments of the knee joint following trauma.

In the non-osseous skeletal tissues, calcification is almost always the result of trauma. As a result of trauma, there follows hemorrhage, organization, and, at times, calcification and ossification, as described by Leriche and Policard. A trauma may be so slight, or may have occurred so long a time before the onset of symptoms, that the patient does not think of it in relation to his present complaint. Deposits, however, may be present without symptoms.

One distinction, however, must be recognized in this syndrome as it occurs in the hip and as it occurs in the shoulder. Because of its relatively small size and limited area of insertion, the supraspinatus tendon is more often liable to complete rupture than is the larger tendon of the gluteus medius. In the latter instance, a relatively large area of degeneration can occur, completely involving the tendon. Therefore, at the hip, it is not necessary to postulate a ruptured tendon in the presence of evident calcification.

The following five cases are reported in detail because they demon-

FIG. 1

Case 1. Roentgenogram of the left hip joint before operation, showing a calcified deposit on the under surface of the gluteus medius, not connected with the greater trochanter.

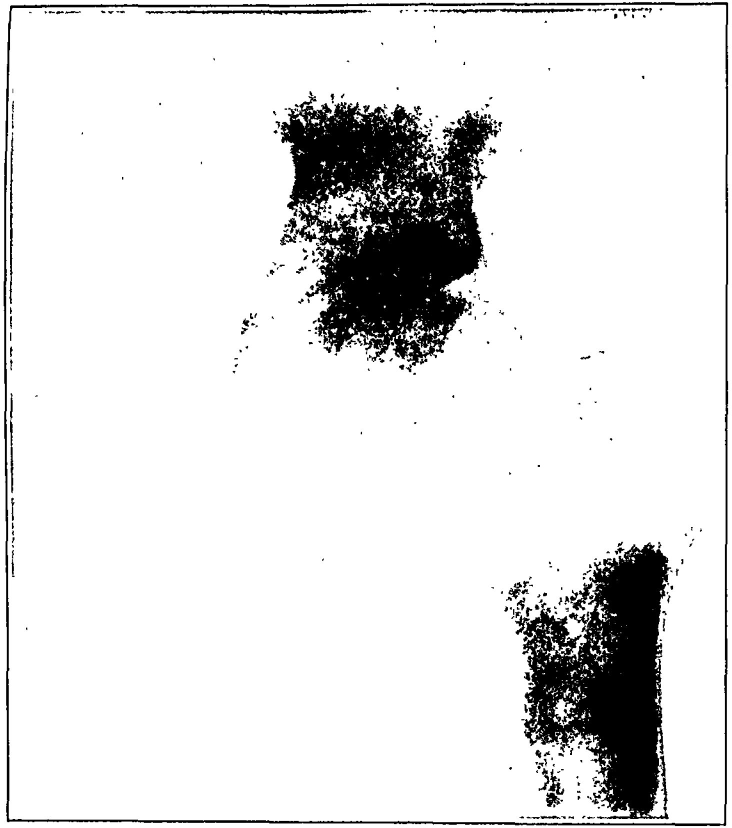

FIG. 2

Case 1. Postoperative roentgenogram of the left hip joint, revealing complete extirpation of the calcified deposit.

strate varying aspects of the syndrome under discussion. Taken as a group, they give a composite picture of calcified deposits about the greater trochanter.

CASE REPORTS

CASE 1. C. L., a male, aged fifty-five was admitted to the Hospital for Joint Diseases on February 5, 1934. He had been well until October 1933, when he had fallen out of a tree, injuring the region of the left hip. The pain in the hip had persisted and the patient had been unable to work.

Examination of the injured hip revealed that the extremity was held in slight adduction. There was no tenderness. Adduction and external rotation were complete. There was marked limitation of abduction, slight limitation of internal rotation, flexion to 90 degrees, and extension to 170 degrees. Beyond these limits, the patient had pain in the region of the hip. Roentgenographic examination (Fig. 1) revealed a calcified deposit in the region of the capsule of the left hip. The blood count and urine were normal. The Wassermann, Kahn, and gonorrhoea complement fixation tests were all negative.

The patient was operated upon on February 6, 1934. Directly beneath the deep fascia a huge mass of bone was felt. The tensor fasciae femoris was retracted outward. A mass of bone, two inches in length and one and one-quarter inches at its widest part, was resected. This mass was embedded in the soft tissues adjacent to the joint capsule on its deep surface, the gluteus medius on its outer aspect, and the rectus femoris in front. The bone was easily shelled out. The specimen consisted of a flat piece of bone, covered on one side by ligamentous tissue; on the opposite side connective tissue and fat were attached. Microscopic examination showed the flat mass to consist of cartilage which was undergoing ossification. On one surface, the connective tissue contained more fat, and a few necrotic muscle fibers were to be seen. The roentgenogram (Fig. 2), taken after operation, revealed complete absence of the calcified plaque previously reported.

After his discharge from the Hospital, the patient complained of slight stiffness, for which he received diathermy, baking, and massage. After seven treatments, he had a complete range of painless motion. The patient has been back at his former occupation of tight-rope walking since October 3, 1934.

CASE 2. N. M., a male, aged fifty-six, complained of pain in the right hip joint, with radiation down the outer aspect of the right thigh, of eighteen months' duration. For the past two years, the patient had worn a truss for hernia.

Examination showed the patient to be in good general condition. He walked without a limp. There was moderate tenderness over the right greater trochanter. The motion of the hip was free in all directions, except abduction and internal rotation, which were limited to 20 degrees and 15 degrees, respectively. The patient had an incomplete, indirect right inguinal hernia. The ring of the truss rested on the right greater trochanter.

Roentgenographic examination (Fig. 3) disclosed a calcified bursa of the right greater trochanter. Diathermy brought no relief; therefore, excision of the bursa was advised, which the patient refused.

CASE 3. M. B., a female, aged fifty-eight, complained of slight but steady pain in the region of the left hip. There was no history of trauma. The patient stated that she had been perfectly well until two years previously, when she had been awakened from sleep by a sharp pain in the region of the left hip. The pain had gradually decreased, but had never entirely disappeared.

Examination showed that the patient walked by dragging the left lower extremity. Active abduction was painful and was limited to 30 degrees. There was tenderness over the hip joint and over the greater trochanter. The roentgenogram (Fig. 4) showed a small bone lying in the gluteus medius over the greater trochanter.

CASE 4. R. P., a female, aged forty-seven, attributed her illness to a fall on the left

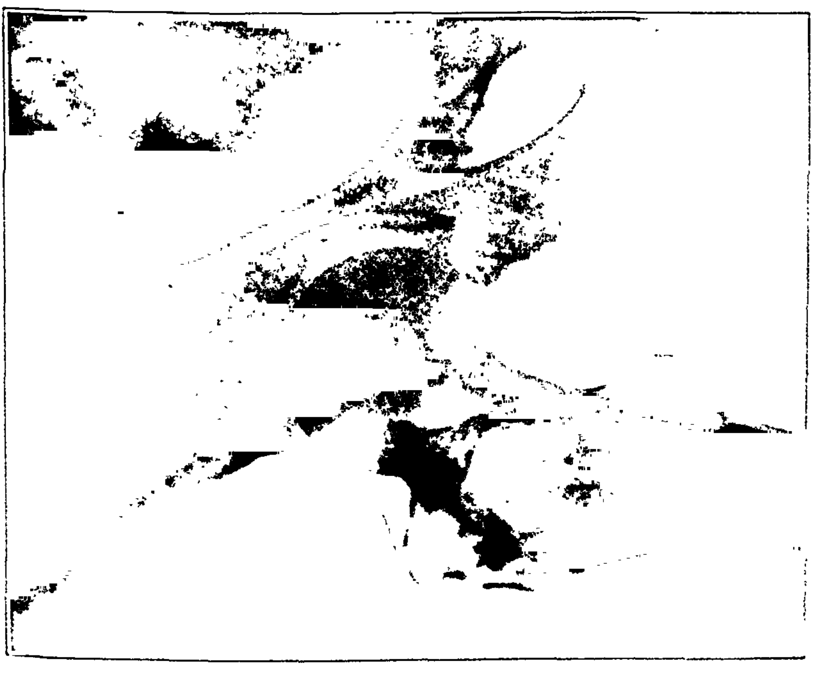

Fig. 3

Case 2. Calcified deposit within the bursa of the gluteus medius.

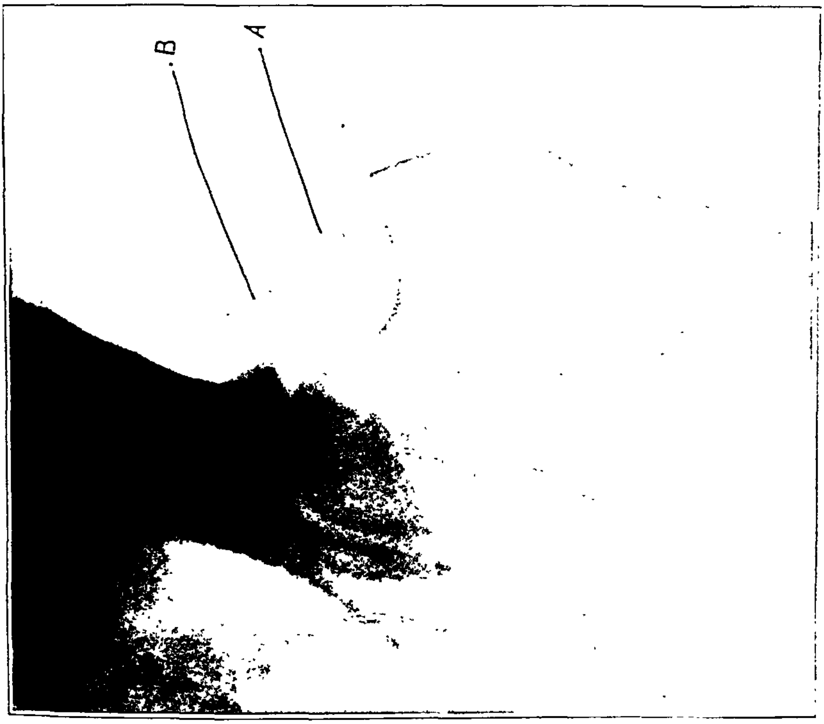

Fig. 4

Case 3. Roentgenogram showing:
A. Small calcified deposit in the tendon of the gluteus medius over the greater trochanter;
B. Gluteus medius.

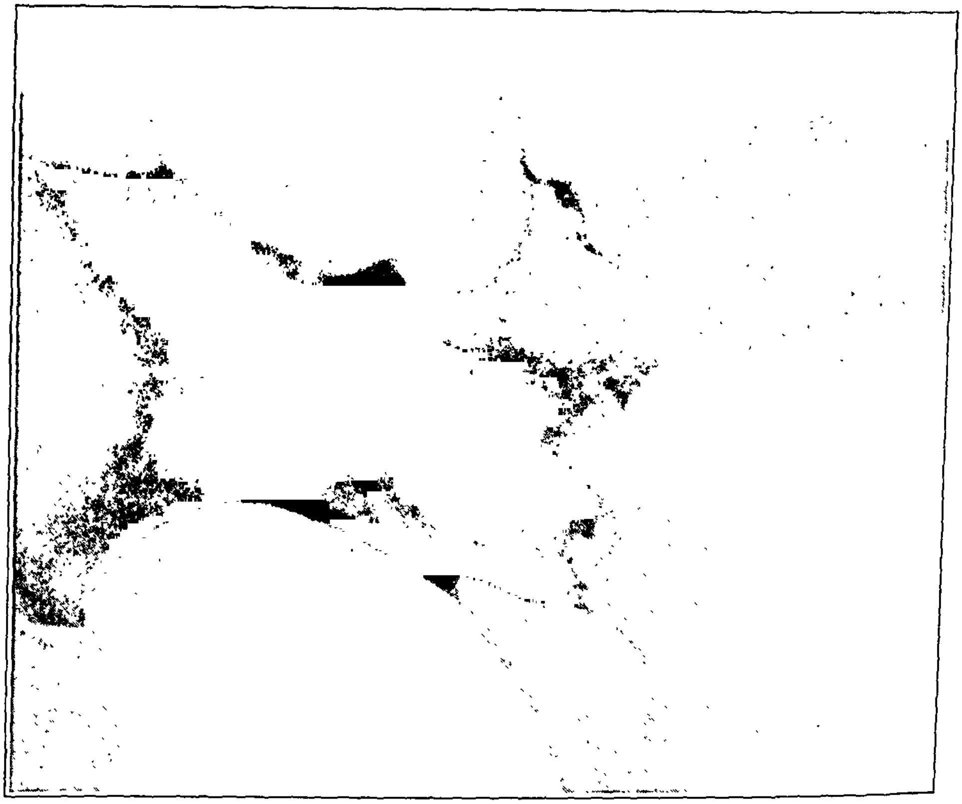

FIG. 5

Case 4. Osteoperiosteal spur on the greater trochanter.

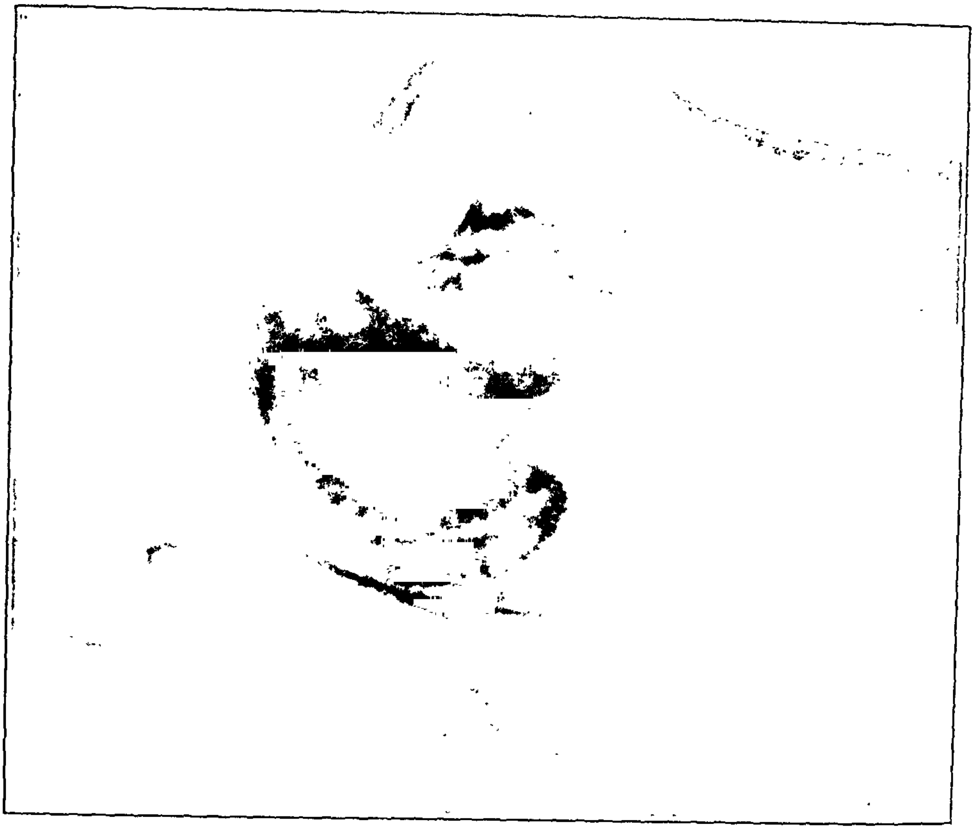

FIG. 6

Case 5. Calcified deposit in the bursa of the gluteus medius, with osteo-arthritis of the left hip.

hip two months before admission. The roentgenograms taken at that time were said to have been negative. Pain had been present in the region of the left hip for three weeks; then it had subsided. Two weeks before admission, the pain had recurred.

Examination showed that the patient walked with a slight limp on the left side. There was limited motion in all directions and tenderness over the left greater trochanter. Roentgenographic examination (Fig. 5) showed an osteoperiosteal spur on the left greater trochanter.

The patient received seven diathermy treatments, with some relief of pain.

CASE 5. M. B., a male, aged forty-six, complained of pain in the left hip and a limp of eighteen months' duration. One and one-half years before admission, he had fallen, injuring the left hip. Pain had been present for about one week; then it had gradually subsided. Six months later, the pain had recurred and had persisted. At no time had the pain been severe.

Examination showed that the patient walked with a limp on the left side. Motion in the left hip joint was limited in all directions. There was no tenderness over the greater trochanter. There was three-eighths of an inch of shortening of the left lower extremity.

The roentgenogram (Fig. 6) revealed an arthritis of the left hip, with calcification of the bursa.

The patient received thirteen diathermy treatments, without any apparent improvement. Operative removal of the calcified mass was advised, but was refused by the patient.

SUMMARY

1. Calcification in the region of the greater trochanter should be suspected in cases of pain in the region of the hip.

2. There are three common locations for calcified deposits in the region of the greater trochanter.

3. The pathogenesis of this syndrome is analogous to the syndrome which occurs in the supraspinatus muscle at the shoulder.

4. Deposits may be demonstrated in the roentgenogram, and the patient may have no signs nor symptoms. The most frequent clinical sign is reflex spasm of the gluteus medius.

5. Review of the literature and our experience show that surgical removal of the deposit results in a cure.

The authors wish to thank Dr. Samuel Kleinberg for permission to use several of his cases, and Dr. E. M. Bick for his assistance in preparing the manuscript.

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TOTAL DISLOCATION OF THE ASTRAGALUS

BY JOSEPH I. MITCHELL, M.D., MEMPHIS, TENNESSEE

Complete and simultaneous dislocation of the astragalus, from the tibiotarsal mortise, from the calcaneum, and from the scaphoid is of infrequent occurrence and, although the dislocation is described in most text-books on traumatic surgery, the mechanism is not clearly understood. Five varieties of this lesion have been recognized,—namely, forward, backward, medial, lateral, and rotary. According to Stimson, the most common variety is the forward dislocation, of which the following case is an example.

I. T., a negro woman, aged thirty-five years, weighing 231 pounds, was admitted to the Orthopaedic Service of the Memphis General Hospital on February 25, 1935, eighteen hours after injury to the right ankle. The right foot and lower leg were swollen. The knee was held flexed and the foot was displaced medially, inverted, and in equinus. The medial malleolus was not palpable; the lateral malleolus was prominent. A bony mass

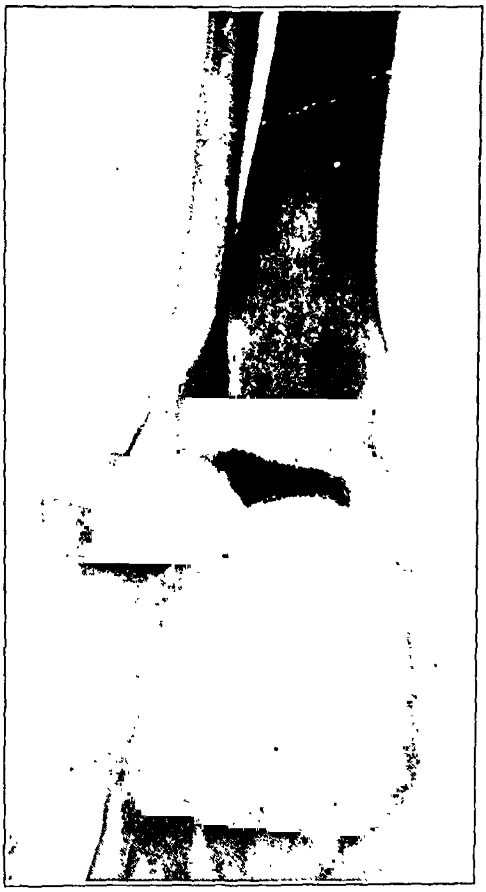

Fig. 1

Anteroposterior view of the ankle showing lateral displacement of the astragalus from its articulation with the tibia and the calcaneum.

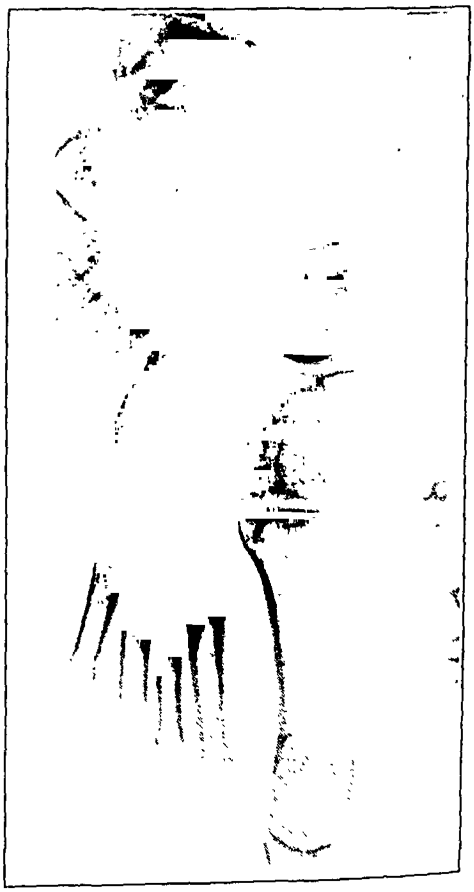

Fig. 2

Anteroposterior view of the foot, showing the head of the astragalus displaced from the scaphoid and lying lateral to the cuboid.

FIG. 3
Lateral view, showing anterior displacement of the astragalus.

was present on the dorsal surface of the foot, and the skin overlying this mass was stretched taut and was beginning to slough.

Roentgenograms of the foot and ankle, made in several planes, demonstrated a complete dislocation of the astragalus laterally and anteriorly from its normal position. The body of the astragalus was displaced anteriorly, but was still partially within the tibiofibular mortise. The inferior surface was separated completely from the calcaneum, and the head of the astragalus was lying lateral to the cuboid bone. The other tarsal bones were in a normal position and no fracture was identified.

FIG. 4
Roentgenogram of the foot and ankle after closed reduction and application of a cast.

Preparations were made for an operative reduction or possible excision, since it was believed that successful reduction by closed manipulation was doubtful. With the patient under spinal anaesthesia, which produced complete muscular relaxation, manipulation was performed in the following manner. One assistant supported the leg with the knee flexed at a right angle. A second assistant grasped the heel and forefoot, making strong traction. Direct pressure with both thumbs was then exerted over the prominent head and body of the astragalus. *The displacement was quickly and easily reduced at* the first attempt and the normal contour of the foot was restored. A plaster cast, extending from the base of the toes to the knee, was applied, and a balsa-wood foot plate was incorporated for walking.

The patient was discharged from the hospital five days later, bearing full weight. The first cast was changed after six weeks and a second cast was worn for four weeks. When the patient was last seen in the Out-Patient Department five months after the injury, function of the ankle was practically normal.

The patient's account of the accident was that she had slipped on ice and had fallen down four steps. It was impossible to ascertain the exact mechanism of the injury, but, since the heel of the right shoe was broken, it was presumed that this shoe heel had caught on the step. As the patient fell forward, the foot was forced into strong plantar flexion, thus widening the anterior aspect of the ankle joint. At the same time, pressure from the weight of the body was exerted on the astragalus from above and behind. In this manner, the astragalus was presumably squeezed from its position, as a pea is squeezed out of a pod.

STIMSON, L. A.: A Practical Treatise on Fractures and Dislocations. Ed. 8. Philadelphia, Lea and Febiger, 1917.

INTERESTING MALIGNANT BONE TUMORS

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The following six cases of malignant bone tumors are interesting from a diagnostic viewpoint and include: (1) metastatic carcinoma of the breast, resembling hyperparathyroidism; (2) endothelioma of the pubis; (3) Hodgkin's disease, with osseous metastases; (4) metastatic adenocarcinoma, resembling primary osteogenic sarcoma; (5) metastatic carcinoma to bone from the cervix; (6) telangiectatic sarcoma of the humerus.

The problems for diagnosis have in most cases been clinical as well as roentgenographic. No effort has been made in this paper to review the literature.

CASE 1. A. C., white, female, aged fifty-six years, a housewife. (Registry of Bone Sarcoma, No. 1849.)

The patient was admitted to Nassau Hospital on February 26, 1935. Twelve years previously, a radical breast amputation had been done for carcinoma. Eight months before admission, pain had developed in the right elbow, with limitation of motion. Six months later, a marked constipation had developed. She had lost sixty-five pounds in weight during the year. The pain in the elbow had persisted and become constant. Upon admission, the patient complained of severe pain in the lumbosacral spine of a week's duration, with radiation down the posterior aspect of the left thigh.

Physical examination disclosed an adult in poor general condition. The right elbow was swollen, with extreme limitation of motion in all directions. There was tenderness over the humeral shaft. Flexion deformities of both hips were present, with tenderness over the ilium and upper third of the left femur.

The blood Wassermann and urine tests were negative. The blood count showed a secondary anaemia.

Blood examination, on one occasion, showed:

Calcium—14.4 milligrams per 100 cubic centimeters
Phosphorus—3.5 milligrams per 100 cubic centimeters

and a later examination showed:

Calcium—12.0 milligrams per 100 cubic centimeters
Phosphorus—3.4 milligrams per 100 cubic centimeters.

Roentgenograms of the right elbow revealed extensive cystic degeneration of the humerus and upper end of the radius and ulna, with destruction of the cortex in some areas.

Roentgenograms of the skull, pelvis, femora, and lumbar spine showed the entire cranial vault to be filled with numerous areas of decreased density without thickening of the tables. The lumbar spine, pelvis, ribs, and femora showed the same changes noted in the humerus.

The patient's condition grew steadily worse during hospitalization. On March 8, 1935, the face was partially paralyzed. A week later, a diffuse bronchopneumonia developed and the patient died on March 16, 1935.

At autopsy, there was found a mass at the anterior edge of the left axilla in the subcutaneous tissues. The pleura was much thickened on both visceral and parietal surfaces and appeared grayish-white and somewhat nodular. In the hilum, and encircling the main bronchi were surrounded by very firm grayish-white tissue. The spleen showed

numerous small zones of grayish-white tissue. Retroperitoneal tissues, extending from the pelvis up into the thorax, revealed numerous deposits of grayish-white, hard tissue apparently in lymph nodes. Some of these were two centimeters in diameter and many were adherent to each other.

The crest of the ilium was revealed on the left side and was found to be greatly thickened. The periosteum was adherent. A portion of the crest of the ilium was removed and section disclosed destruction of the usual cancellous structure and replacement by solid masses of pale tissue of fibrous consistency. The thickness had been increased to about one and one-half centimeters at the crest and to two and one-half centimeters in the body of the ilium. A section of the lumbar vertebrae showed similar alteration of the bone structure. Similar masses of tumor tissue were revealed in the ribs, expanding the usual contours. Such was the case in the third rib, in the axillary line, where the subcutaneous mass was located. The right humeral shaft was encased in an indurated grayish-yellow tissue which infiltrated the muscle attachments. The periosteum was invaded so that it no longer formed a separate layer. The whole marrow cavity appeared to be filled with this hard substance and there was no longer the distinction between cortex and marrow cavity.

The diagnosis was carcinomatous metastasis to the vertebrae, ribs, right humerus, pelvis, left femur, pleura, and to the lymphatics in the hila of the lungs, the posterior mediastinum, and the retroperitoneal tissues.

This case is of interest because of the long interval of time (twelve years) which elapsed between the original mastectomy and the development of the metastatic bone lesions.

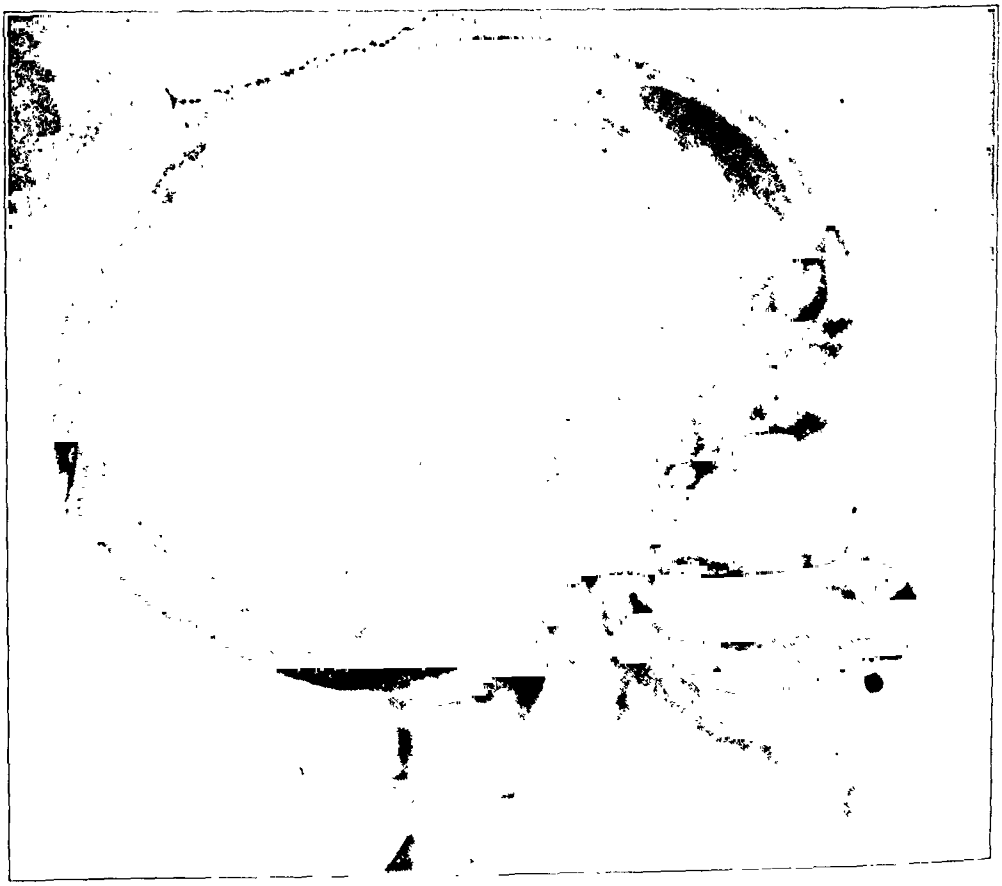

FIG. 1

Case 1. X-ray of skull, March 1, 1935, showing extensive destruction of the cranial tables.

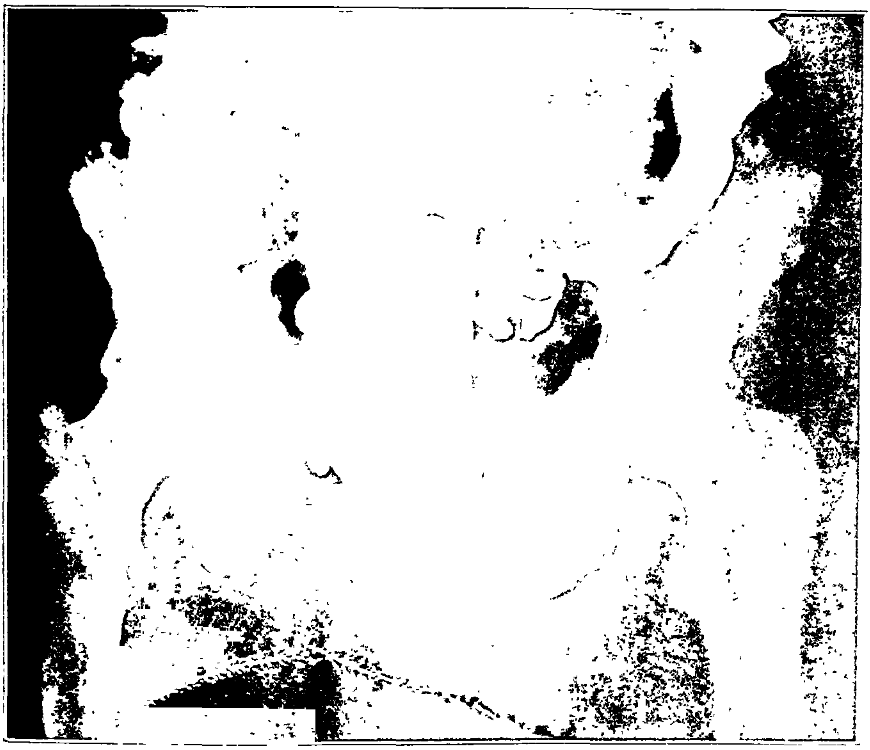

FIG. 2

Case 1. X-ray of pelvis, March 1, 1935, with barium enema, showing extensive destruction of all bones visualized. The cortex here remained intact.

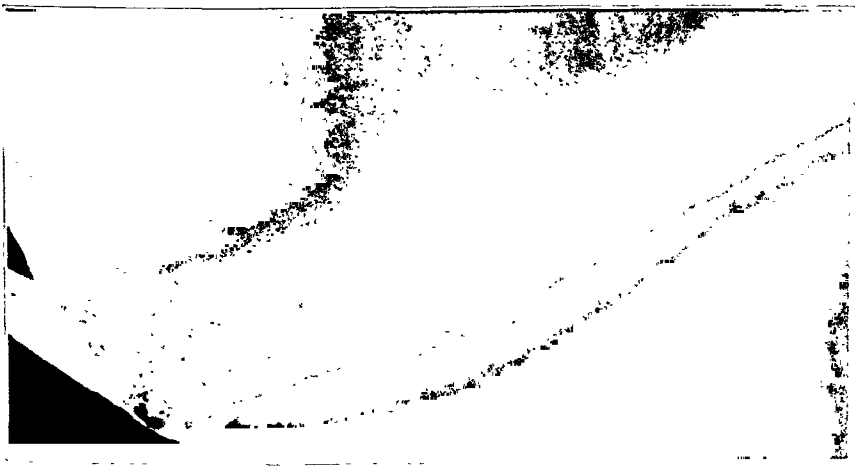

FIG. 3

Case 1. X-ray of right elbow, February 27, 1935, showing extensive osseous changes.

The clinical picture resembles very closely that of hyperparathyroidism, with loss of weight, high blood calcium, low phosphorus, and generalized polycystic changes in the bones. Our original diagnosis in this

case was osteitis brosa ficystica, but biopsy proved this diagnosis to be erroneous.

The increase of blood calcium and the decrease of blood phosphorus occurs in generalized metastatic carcinoma, as well as in hyperparathyroidism. However, the phosphatase figure is the important differential point, as far as the blood picture is concerned. Unfortunately, our laboratory is not equipped to give this reading.

Another differential point, as revealed by the roentgenographic examination, was the fact that these so called cystic lesions in the humerus had broken through the cortex. This condition is generally seen only in malignancy and occasionally in osteitis fibrosa cystica. One more important factor in the differential diagnosis was the roentgenographic appearance of the skull. In this case, the areas of destruction were large, as one would expect with carcinoma, while in osteitis fibrosa cystica the usual picture is that of a fine granular mottling.

One point, however, in favor of hyperparathyroidism was the fact that all the bones which were x-rayed showed a generalized osteoporosis. This finding is frequently the first bone change seen in this disease.

CASE 2. J. S., white, female, aged fifteen years, a student.

The patient was admitted to Nassau Hospital on June 12, 1934, with a history of pain in both knees of five months' duration, loss in weight of twenty pounds, and anorexia.

Physical examination showed hyperpyrexia, tachycardia, and malnutrition. Flexion contractures were present in both knees. Blood counts showed marked secondary anaemia. All other laboratory findings were negative.

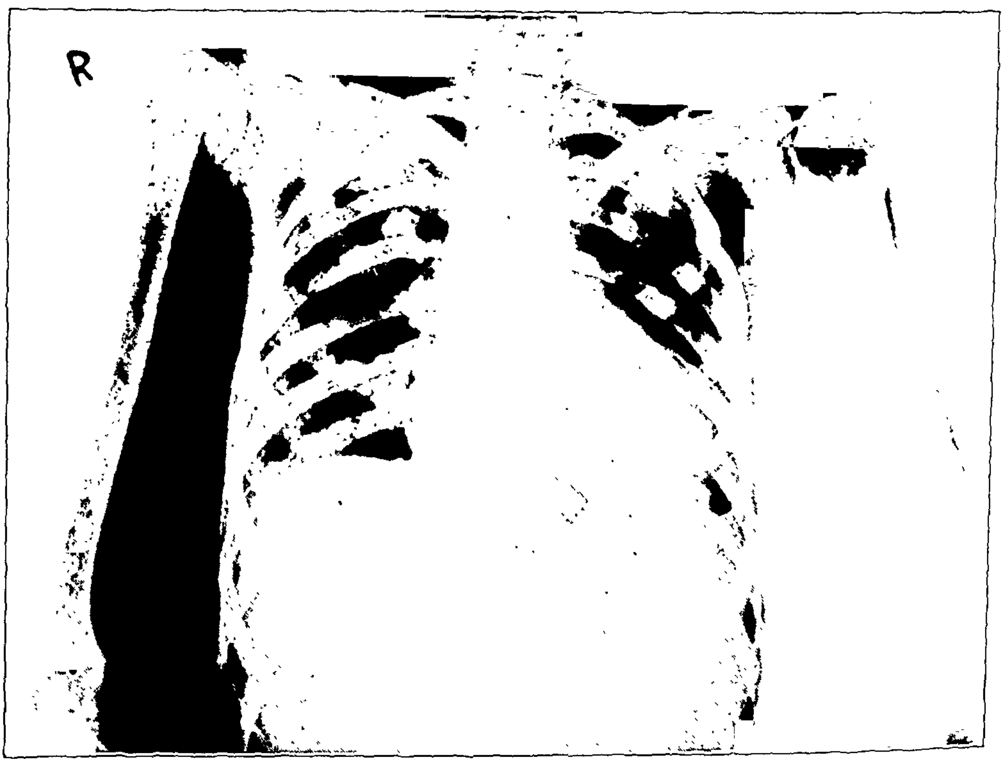

FIG. 4

Case 2. X-ray of chest, August 8, 1934, showing metastatic lesions to lungs, ribs, and shoulder girdles.

The patient steadily became worse, with loss of strength, weight, and appetite. The anaemia increased, and transfusions were given. Roentgenograms of the pelvis showed multiple areas of destruction throughout the pelvis and upper ends of both femora. Destruction was most marked in the horizontal ramus of the left pubic bone and in the ramus of the left ischium. Productive changes had also taken place in this region.

The patient was transferred to the Nassau County Tumor Clinic on August 7, 1934. Physical examination showed an extremely emaciated girl. There was engorgement of the superficial veins of the left side of the abdomen, extending down on the left thigh. The left inguinal region was fuller than the right. There was no tenderness over the pelvis. There was oedema of the left leg and knee. Flexion contractures of both knees were present; the contracture of the left knee was greater than that of the right. Motion of the left hip was very painful.

Fig. 5

Case 2. X-ray of pelvis, August 8, 1934, showing a large destructive and productive lesion of the left pubic bone with extension.

The impression was that this was a case of endothelial myeloma.

Roentgenographic examination of the chest, on August 8, 1934, showed a dense oval shadow in the left lower lobe, due to metastasis. Surrounding it was an inflammatory process. There were also noted multiple small areas of rarefaction in the ribs, the outer end of the right clavicle, and the upper end of the right humerus.

Roentgenograms of the pelvis showed multiple areas of destruction throughout, involving the femora and the sacrum. There was a more advanced lesion in the left pubis, with a large amount of new bone.

On September 4, 1934, radiotherapy was administered to the pelvis. Later, ptosis of the right eyelid developed, with diminution of all external ocular movements. The patient complained of severe pain in the right temporal and frontal areas. The right temporal region, including the orbit, was then irradiated, with relief of symptoms. Several weeks later, pain developed in the chest, due to metastases, and the left chest only was irradiated. The patient's condition followed a downhill course and she died in a coma on November 11, 1934.

Autopsy revealed an extremely emaciated dehydrated child. There were nodules attached to the ribs in the region of the costochondral articulations. The skull presented numerous nodules, ranging in diameter from one to three centimeters. There was a nodule in the left orbit above the globe. There were numerous nodules beneath the parietal pleura and attached to the ribs. The right lung was adherent to the parietal pleura over some of these nodules. In the lower lobe of the left lung, near the mediastinal border, there was a large tumor mass. The liver showed a few nodules of tumor, and the spleen contained a single nodule. The bladder was displaced to the right and posteriorly by a tumor mass in the pelvis. There were numerous nodules of tumor in all of the ribs, most marked at the costochondral junction. The nodules on the right side of the chest were one and five-tenths centimeters in diameter at the costochondral junction; those on the left side were smaller. There were smaller metastases present in the bodies of the ribs. Involving the pubis, was a large, irregular, nodular mass, extending somewhat more to the left than to the right. This mass extended downward on either side along the pubis and down the ascending ramus of the ischium. On the left side, the iliac vein was involved in a mass and contained a solid cord of tumor tissue up to its junction with the vena cava. The color of the tumor was an unusually bright yellow. Other areas of the tumor were gray in color and in some places were necrotic.

The final pathological diagnosis by Dr. F. W. Stewart, of New York City, was as follows: "This case presents certain peculiarities; the cells are in many places too spindle-shaped for the usual endothelial tumor. Yet there are rosettes, peculiar whorls, and, particularly in the bronchial node, the structure corresponds to endothelioma. The calcification which, in gross, I thought was against endothelioma is in areas of hemorrhage and necrosis and hence does not militate against the diagnosis of endothelioma. I think we are justified in accepting the tumor as a form of endothelioma of bone."

In this case, the left side of the chest received a single high-voltage x-ray treatment. The tumor masses, arising from the ribs beneath the pleura on the posterior aspect of the thoracic cavity, were larger and more numerous on the right than on the left. The apparent regression of the tumor on the irradiated side of the chest is noteworthy.

This case presents the usual difficulty of making a diagnosis before osseous changes have occurred. Symptoms persisted for eight months before positive roentgenograms were obtained. We have recently seen a case of metastatic epidermoid carcinoma of the ilium in which the same symptoms were noted.

In both cases, the pain was referred to the knees, with later develop-

FIG. 6

Case 3. X-ray of the pelvis, January 29, 1935, showing periostitis of the ilium and femur, as well as osteoblastic changes in the innominate bones and lumbosacral spine.

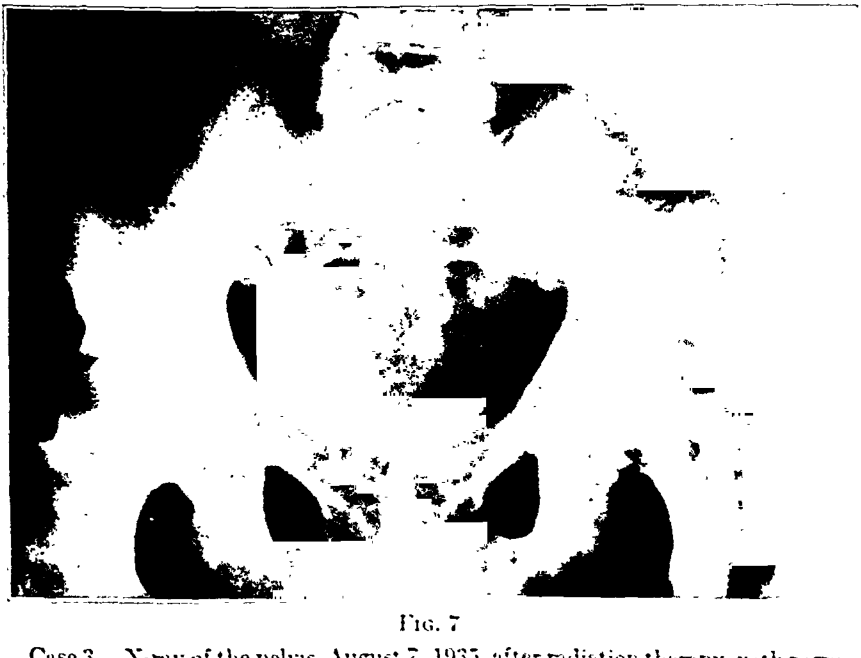

FIG. 7

Case 3. X-ray of the pelvis, August 7, 1935, after radiation therapy, with regression of the tumor.

ment of flexion contractures. It might be of help in treating patients with obscure pain in the knees without evident cause to be on the watch for a primary neoplasm of the pelvis.

CASE 3. A. F., white, male, aged twenty-two years, a farmer.

The patient was admitted to Nassau Hospital on January 29, 1935. Five months previously, pain had developed in the sacral region. This pain was described as a steady dull ache, and it had not been relieved by medication. Three weeks prior to admission, the pain had become worse in back and had radiated to both thighs. Two weeks before admission, there had been some vomiting after meals. The patient stated that he had felt very weak for several months and had been unable to work. He had lost twenty-five pounds in five months. There was anorexia.

Physical examination showed an adult male, acutely ill, with generalized adenopathy. There was tenderness over the sacrum and the sacrococcygeal region, and marked tenderness over both acetabula.

Roentgenographic examination of the pelvis, on January 29, 1935, showed a generalized sclerosis of bone which appeared to involve the sacrum and the lower lumbar vertebrae. Along the lateral margins of the iliac bones, there was a periosteal reaction, extending down to just above the acetabula. On the left side the sun-ray appearance was evident. Along the medial margin of the neck of the right femur and extending down the shaft for some distance, there was a periostitis similar in all its characteristics to that seen along the left iliac bone. On the lateral side of the right femur there was simply thickening of the periosteum.

The blood Wassermann and urine tests were negative. Blood counts showed mild anaemia and leukocytosis.

With rest in bed, the subjective pain was relieved and the vomiting ceased. The temperature was 99 to 100 degrees continuously. Biopsy of an inguinal node was done on February 2, 1935. The microscopic diagnosis was Hodgkin's disease.

On February 8, 1935, the patient was referred for deep x-ray therapy. The pain in the pelvis was entirely relieved by x-ray irradiation. In June, the patient returned, complaining of pain in the dorsal spine, which was controlled by irradiation.

In this case of Hodgkin's disease, the patient presented osteoblastic lesions in the pelvis and the upper femora. The diagnosis would have been difficult, if no pathological tissue could have been removed.

We have seen more osteoblastic metastatic lesions than osteoclastic metastatic lesions. The unusual feature in this case is the extensive bone involvement. It is usually limited to one or perhaps to two sites, as illustrated by the roentgenogram of another case (Fig. 8).

The patient reacted very favorably to small doses of deep x-ray therapy and, as the follow-up roentgenograms show, the osteoblastic changes, particularly those in the pelvis, underwent regression. In addition, the periostitis noted along the ilia and left femur made the diagnostic problem slightly more difficult, for this same reaction has been frequently associated with other bone lesions.

CASE 4. E. H., white, male, aged seventy-six, a foreman. (Registry of Bone Sarcoma, No. 1847.)

The patient was admitted to the Nassau County Tumor Clinic on December 28, 1934, with a history of pain in the left arm of six months' duration. Two months before admission, the pain had become so severe and constant that the patient could not sleep. The patient stated that he had been unable to use his arm for three weeks and that for two weeks there had been a swelling in the middle third of the left arm.

FIG. 8

X-ray of spine, showing solitary metastatic lesion.

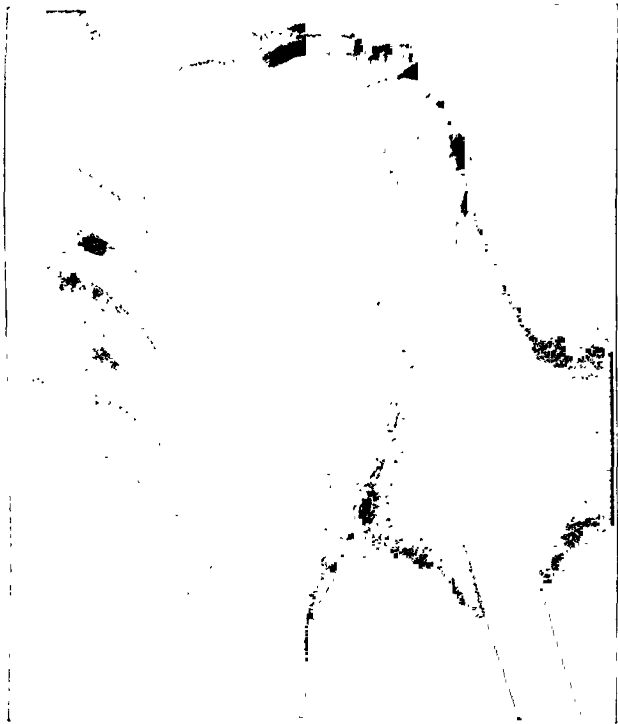

FIG. 9

Case 1. X-ray of the left humerus, December 20, 1934, showing central destructive lesion in the shaft of the humerus.

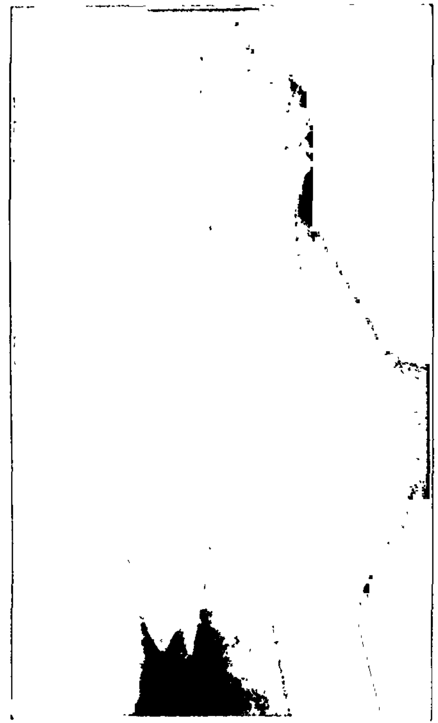

FIG. 10

Case 4. X-ray of the left humerus, February 5, 1935, showing progression with destruction of the cortex and extensive soft-tissue invasion after radiotherapy.

The physical examination was negative, except for the local findings in the left shoulder. Motion of the left elbow was limited by pain, and the arm was held fixed at the side. There was a swelling of the middle third of the left arm, that was soft, semifluctuant, and extremely painful and tender. The shaft of the bone was enlarged. A pathological fracture was present.

The Wassermann and urine tests were negative. Roentgenographic examination of the left humerus showed an area of destruction in the middle third, involving the medullary canal and invading the cortex. Productive bone changes were seen in the cortex surrounding the tumor.

An aspiration biopsy was done on January 5, 1935, and the pathological report was metastatic adenocarcinoma. The kidney was the most probable origin.

In view of the patient's age, radiotherapy to the humerus was instituted. Pain in the arm increased in severity with the increase in swelling, and a disarticulation of the left humerus was done on February 11, 1935. In May, pain developed in the chest and the patient brought up blood-tinged sputum. The liver was enlarged and a nodule was palpable. There was a moderately severe jaundice. The patient had lost a large amount of weight and complained bitterly of pain in the right flank. He gradually failed and died on May 30, 1935. No autopsy was permitted.

This patient presented a rapidly growing solitary tumor of the humerus, which was thought to be a primary osteogenic sarcoma. The pathological report of metastatic adenocarcinoma could not be proved, because of the lack of an autopsy. An exhaustive search was made for a primary lesion, with negative results.

A solitary metastatic lesion in this location is exceedingly rare. The

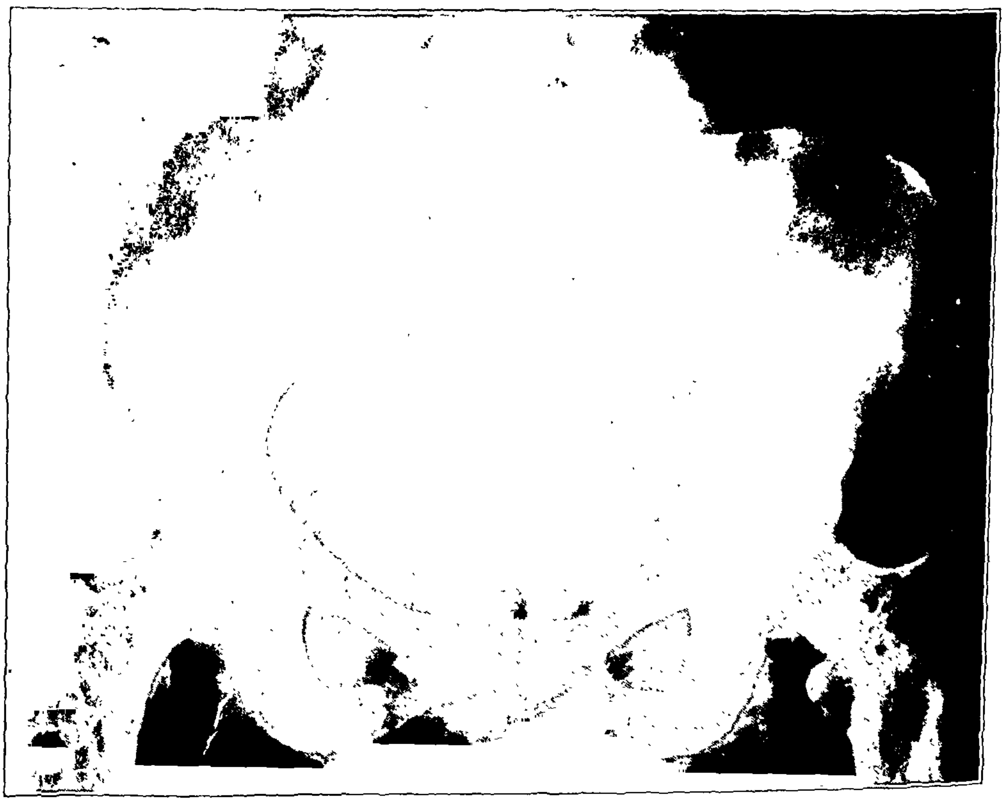

Fig. 11

Case 5. X-ray, January 22, 1935, showing multiple destructive lesions of the pelvis and femora.

tumor was expanding the shaft and acted in its course very much like a primary lesion. The only point against diagnosing this tumor as a sarcoma was the age of the patient.

Case 5. M. Y., female, adult, aged fifty-three, a housewife.

The patient was first seen at the Nassau County Tumor Clinic on November 21, 1933. She had had a normal menopause thirteen years previously. For three months prior to admission, she had had rather severe flowing at monthly intervals. She had been bedridden for three weeks because of the bleeding.

Physical examination showed an obese adult in good condition. The examination was negative except for stenosis of the vaginal canal. The cervix was involved by an ulcerated bleeding tumor.

Biopsy of the cervix showed plexiform epidermoid carcinoma. Deep x-ray therapy was given, followed by a cervix tandem of radium. Ten months later, there was no evidence of disease in the cervix or the parametria. On October 8, 1934, the patient struck her right shin against a chair. The foot then became swollen and tender. Pain increased. There was tenderness of the entire right leg with slight oedema. Crepitation was present.

X-ray of the right leg showed irregularity in the trabecular structure of the upper third of the tibia, extending down the shaft. There was marked loss of bone density and just below the tibial tubercle the cortex appeared to be entirely destroyed. There was a fracture through the junction of the upper and middle thirds. There were also metastatic lesions, of the osteolytic type, to the skull, spine, and pelvis. Biopsy of the right tibia, on October 10, 1934, showed metastatic epidermoid carcinoma. Radiotherapy to the upper two-thirds of the right tibia was given at this time with some improvement. Four months later pulmonary metastases developed, and the patient died on February 24, 1935.

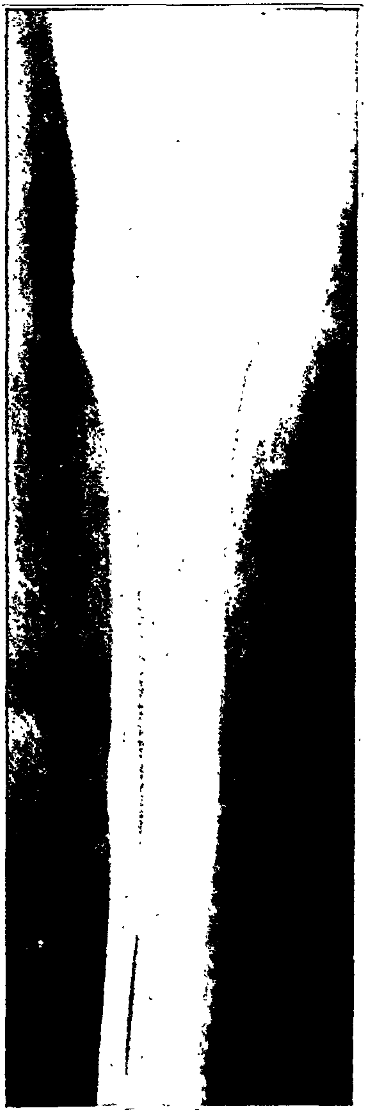

Fig. 12

Case 5. X-ray of tibia, October 8, 1934, showing metastatic carcinoma of the tibia with pathological fracture.

This case is of interest because of the presence of generalized bone metastases of a carcinoma of the cervix. As far as we know, no metastatic bone lesion in the tibia from the cervix has ever been reported.

Case 6. C. S., white, male, aged forty-four, a mechanic. (Registry of Bone Sarcoma, No. 1846.)

The patient was seen in the Nassau County Tumor Clinic on November 6, 193[illegible]. He had had pain in the right shoulder, with limited motion, for two months. The pain had become worse in spite of rest. Three weeks before admission, a swelling had developed, and the pain had increased. The patient was unable to work.

FIG. 13

Case 5. X-ray of skull, January 22, 1935, showing extensive metastatic lesions.

Physical examination was negative, except for a swelling of the right shoulder, which extended beneath the pectoral muscle. There was a dense, firm mass, the size of a large grapefruit, in the region of the head of the humerus. All motions were painful and limited. The grip was weak.

Roentgenographic examination of the right shoulder revealed a large, expanding, destructive tumor in the upper end of the shaft of the humerus. The osseous destruction was almost total. Some osseous production, external to the limits of the bone, was seen in the soft tissue. The appearance was typical of osteogenic sarcoma of the osteolytic type.

The Wassermann and urine tests were negative. Secondary anaemia was present. An interscapular thoracic amputation was done on November 12, 1934. The diagnosis of the amputated specimen was telangiectatic osteolytic sarcoma.

Roentgenograms of the chest, on December 10, 1934, showed pulmonary metastases. Radiotherapy was instituted on December 12, 1934. Roentgenographic examination of the chest, on December 18, 1934, showed a definite metastatic nodule in the right upper lobe and right lower lobe and small nodules in the left lower lobe.

The patient's condition grew worse, and he died on March 25, 1935.

In this case, the nature of the lesion was discovered late in its course and, therefore, lung metastases were to be expected and were probably present at the time of operation which was necessary to relieve pain.

In this type of rapidly growing tumor, it is imperative that an early diagnosis be made, if any hope is to be expected from surgery.

FIG. 14

Case 6. X-ray of the right shoulder, November 6, 1934, showing an extensive osteolytic lesion of the humerus.

CONCLUSIONS

Metastatic or primary bone tumors frequently offer difficult problems for diagnosis.

Subjective symptoms may be present for a long time before positive x-ray findings are obtained.

In cases of suspected metastatic bone lesions, radiation therapy should be given for relief of pain, even with negative roentgenograms.

Other findings from the cases studied are as follows:

Case 1: There is apparently no definite time limit for bone metastases to follow carcinoma of the breast, even after radical surgery. This is another example of how little faith we can place in our so called five-year cure for cancer. Occasionally, generalized metastatic carcinoma may be confused with our growing knowledge of hyperparathyroidism.

Case 2: In primary neoplasms of the pelvis, pain is radiated to one or both knees without early physical signs. Later, contractures develop and the roentgenographic findings become manifest. This has been true in our two cases of malignant pelvic tumors and may be of help in diagnosis.

Case 3: Alleviation of pain is the important treatment for Hodgkin's disease, particularly when bone is involved, and x-ray therapy plays its part here. Periostitis in bone lesions frequently confounds the diagnosis instead of aiding in its clarification.

Case 4: This case represents a tumor which gives all the clinical evidence of being primary, but pathologically is proved to be of secondary origin. It is well recognized that small undiagnosable primary lesions frequently exist and the only evidence is their secondary manifestations.

Case 5: This is a case of proved epidermoid carcinoma of the cervix, which was apparently cured by radium and x-ray therapy nine months after admission, as far as the original lesion was concerned. Yet, within

fourteen months of the first admission, the patient died of extensive generalized metastatic lesions, some of which were unusually located.

Case 6: Telangiectatic sarcoma is a rapidly growing and fatal form of bone malignancy. Early radical surgery is the patient's only salvation. Technically perfect roentgenograms of the chest are of the utmost importance in ruling out metastases.

A GUIDE FOR THE PARHAM BAND

BY S. K. LIVINGSTON, M.D., F.A.C.S., HINES, ILLINOIS

Difficulty is usually experienced by the surgeon in placing a Parham band about the shaft of a fractured bone. Since the author has failed to discover on the market a suitable guide for the Parham band, he has devised the instrument illustrated below, which he has found useful in the treatment of fractures.

FIG. 1

The instrument is simply a modified aneurysm needle. The surface along the lesser curvature of the arc is grooved to contain the band, which is secured through a perforation at the tip by a catgut ligature. The band may be similarly fixed at the base of the handle. After insertion of the band and instrument about the shaft, the catgut ligatures are removed, the band is held in place, and the guide is withdrawn.

COMPOUND CYSTIC BURSITIS OF THE KNEE JOINT

BY L. E. SNODGRASS, M.D., PHILADELPHIA, PENNSYLVANIA

The following case is presented because of its unusual occurrence.

M. S., a white male, aged nineteen years, entered the surgical dispensary of The Philadelphia Orthopaedic Hospital on Dr. Gill's Service on June 25, 1935, complaining of painless swelling about the right knee. Three years before, while carrying a heavy bag of sugar, he had fallen into the sitting position with his right leg under him, sustaining a twist of the knee associated with swelling. The greater part of this swelling lasted about one week. For the past year, the residual swelling had increased.

Examination of the right knee showed a stable joint, with full range of painless motion. There was a moderate cystic suprapatellar bursitis with some ballottement of the patella. Over the medial portion of the gastrocnemius muscle, there was found a cystic swelling as large as a man's fist. On flexion of the knee with some pressure with his hands, the patient could force this fluid into the suprapatellar bursa. On extension, with pressure over the suprapatellar bursa, he could again distend the lower sac. A diagnosis of compound cystic bursitis communicating through the knee joint was made, and the patient was operated upon on July 1, 1935.

Under general anaesthesia, the lower swelling was incised through a posterior medial incision, and the usual cystic fluid escaped. Suprapatellar pressure greatly increased the force of the escaping fluid. The sac wall was thicker than that of the average cystic bursa and was in intimate contact with the under surface of the deep fascia of the leg on one side and with the belly of the gastrocnemius on the other. It was dissected free in its entirety in a retrograde manner, the sac becoming progressively smaller in diameter until the neck passed around the medial head of the gastrocnemius and joined the synovia of the knee joint. As the neck of the sac wound about the head of the gastrocnemius, it gave off a diverticulum, approximately one inch in length, which lay in the popliteal space. The neck was ligated and cut close to the joint; the stump was touched with full-strength iodine; and the wound was closed without drainage. An incision was then made over the suprapatellar bursa and most of this sac was extirpated.

FIG. 1 *

Examination on October 8, 1935, revealed normal function in the knee joint with absence of fluid.

Davis states that the suprapatellar bursa communicates with the knee joint in eight out of ten cases. He also states that, of the posterior bursae, the one under the inner head of the gastrocnemius is the most important and often communicates with the joint. The popliteal ganglion usually originates in this bursa.

In the patient whose case is reported, both the suprapatellar bursa and the medial posterior bursa communicated with the knee joint, permitting the free passage of fluid from one to the other through the joint.

DAVIS, G. G.: Applied Anatomy. The Construction of the Human Body Considered in Relation to Its Functions, Diseases, and Injuries. Ed. 5, pp. 578–579. Philadelphia, J. B. Lippincott Co., 1918

* For this photograph, the author is indebted to Dr. Irvin Stein.

OSTEOCHONDRITIS DISSECANS OF THE PATELLA

A Case Report

BY CHARLES ROMBOLD, M.D., F.A.C.S., WICHITA, KANSAS

Having found no recent case reports of osteochondritis dissecans of the patella, the writer presents the following case:

J. F., a male, aged twenty-four years, had been active in high school and college athletics for six years with a symptomless left knee. Approximately eighteen months before examination and during the basket-ball season, without any specific injury, some ache and lameness were noted in the knee. This ache was indefinite and was not associated with any particular position or movement, but was severe enough to cause the patient to seek relief. The patient obtained relief from pain by wearing an elastic knee brace during play. Pain was precipitated when the brace was removed.

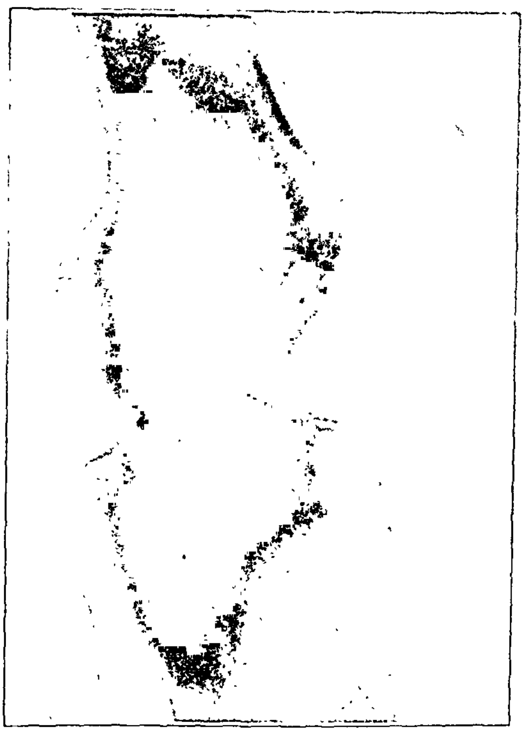

FIG. 1

Lateral view of the patella, showing the osteochondritic focus.

A few months after the initial appearance of the pain, the patient was forced to stop broad jumping principally because of the weakness in the knee. The patient continued running the quarter mile, however. The symptoms of pain and weakness increased in severity during the second basket-ball and track season, until they became severe enough to cause the patient to seek surgical relief. The pain was always diffuse with possibly some localization on the articular surface of the patella. The aching in the knee was increased with long flexion of the joint and was relieved by extension of the knee.

The general physical examination revealed no pathology as possible foci of infection nor glandular disturbance. The only positive findings in the knee were a slight increase in the joint fluid, which showed normal cytology on aspiration, and pain and crepitation when the lower pole of the patella was apposed to the femur. There was atrophy of the left thigh amounting to three-quarters of an inch.

Under local anaesthesia, an arthrotomy of the knee was performed. There was no unusual amount of fluid in the knee; the synovia was neither injected nor apparently abnormal. The menisci were firmly attached and their free edges were not abnormal. The crucial ligaments were competent. The articular cartilage of the femur and tibia was smooth, glistening, and of normal color. There was a band of fine longitudinal striations, about one centimeter in width and three centimeters in length, in the cartilage of the intercondylar notch. These striations represented the area of contact made with the femur by a defect in the patellar cartilage. There was a defect in the cartilage lying equidistant from the lateral and medial surfaces of the patella and in the lower pole. This defect was approximately round and about one and one-half centimeters in diameter. The circumference of the defect was marked by a yellowish, dull,

raised border of the articular cartilage, about one millimeter in width. Within the circumference of the defect, the cartilage was somewhat dull, but of about the same color as the balance of the articular cartilage. By placing a probe in the center of the defect and moving the probe, motion could be detected between the patella and the defect.

After the raised border of the defect had been incised throughout its circumference, the plug of cartilage and bone was lifted from its bed. There was no attachment between the fragment removed and the patella except the elevated discolored circumference of articular cartilage. There was no bleeding from the base of the defect when the plug was removed. Firm bone, without any apparent covering of soft tissue, lay in the base of the defect.

The pathological report by Dr. C. A. Hellwig was as follows:

"The specimen measures two by one and two-tenths centimeters. One-half is eight millimeters thick; the other half, only two millimeters thick. The articular or cartilaginous surface of the specimen is glistening, smooth, bluish-white, while the patellar or bony surface is irregular, mulberrylike and of brownish color. The cartilage represents about two-thirds of the thickness of the specimen; the balance is osseous.

"The hyaline cartilage shows no evidence of degeneration. The matrix is homogeneous; the cells are perpendicular, well stained, and of uniform size. The deep layer of the cartilaginous portion is calcified and spongy bone is adjacent.

"The bone trabeculae have normal form, although no stained cells are found. The intertrabecular tissue is without blood vessels. Rows of osteoblasts are found lining several bone trabeculae. The intertrabecular tissue is replaced for a short distance from the entire osseous margin by fibrocartilage. This fibrocartilage is connected with, and seems to originate from, the hyaline cartilage covering the articular surface of the specimen.

"Diagnosis: Loose body, consisting of living hyaline cartilage, fibrocartilage, and necrotic bone."

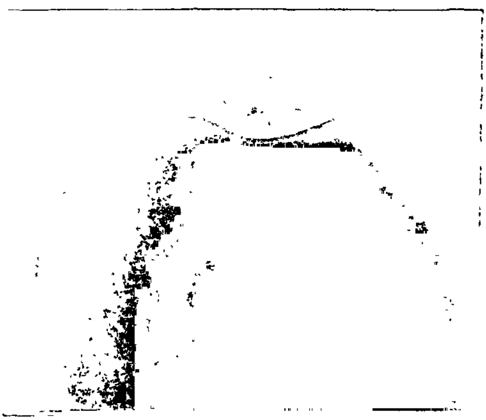

FIG. 2

Longitudinal view of the patella, showing the osteochondritic focus.

This osteochondritis dissecans process in the patella seems to be identical with that process which occurs in the medial condyle of the femur. The subjective symptomatology, which is vague, is similar in the patella and in the femur. The gross appearance of the two lesions is identical and the microscopic pathology is exactly the same.

ACUTE HEMATOGENOUS OSTEOMYELITIS OF THE SCAPULA (ACROMION PROCESS)

BY ROBERT D. FAIRCHILD, M.D., ROCHESTER, MINNESOTA

From the Orthopaedic Department, Receiving Hospital, Detroit, Michigan

Up to 1926, forty-six cases of acute hematogenous osteomyelitis of the scapula had been reported [1]. Since that time, the only instance of this condition found in the literature is that reported by Williams [2] in 1927.

The following case is reported because it is unique, in that the infection primarily involved the acromion process of the scapula, and there was an interesting sequela.

J. T. (P. 1925), a white male, aged eighteen, was admitted to the Receiving Hospital on February 3, 1935, with a history of pain and disability in the right shoulder of two days' duration. There was no history of injury to the shoulder nor of previous bone infection. Some redness and induration, localized to the acromion process of the right scapula, were noted. There was acute tenderness over the point of the shoulder and pain on moderate abduction and circumduction of the humerus. No active foci of infection could be demonstrated either from the history or on physical examination. Except for the shoulder, the physical examination was essentially negative. The temperature on admission was 105 degrees by mouth.

There were 10,500 leukocytes and 4,260,000 erythrocytes per cubic millimeter of blood. There were 12.2 grams of hemoglobin per hundred cubic centimeters of blood. In the blood smear there were 49 filamentous and 40 non-filamentous neutrophiles and 11 lymphocytes. There were 3 leukocytes per high-power field in the centrifuged specimen of urine. The urine was otherwise negative and of low specific gravity (1.003). The Kline test for syphilis was negative.

On the day after admission, a linear incision was made over the spine of the right scapula, extending laterally to a point below the acromion process. Purulent material was revealed overlying the acromion process close to the bone and near the acromioclavicular joint. Drill holes were made into the acromion process and into the lateral end of the clavicle, because of the possibility of clavicular involvement, and the wound was packed with vaselin gauze. A culture of the purulent material showed staphylococcus aureus.

The temperature dropped to 100 degrees two days later, but rose again to 104 degrees on the fifth postoperative day and continued to be high and septic in type. A blood culture, taken on the fifth postoperative day, was incubated for five days and revealed no growth.

A roentgenogram of the right shoulder, taken on the tenth day after operation, showed slight destruction of the acromion process involving the metaphyseal portion. The clavicle did not appear to be involved.

On the eleventh day, an aeroplane spica was applied to preserve abduction of the humerus, and induration was noted in the midline high up in the intrascapular area. With the aid of moist compresses, this induration progressed to swelling and fluctuation. A week later, the aeroplane spica was removed and the acromion process and spine of the scapula were explored. The previous operative wound communicated with a large abscess in the intrascapular region in the midline. The abscess was incised over its dependent portion and drained of at least ten ounces of purulent material. The patient's temperature gradually returned to normal and remained so until discharge, fifty-four days after admission.

Roentgenographic examination of the right shoulder just before discharge showed evidence of osteomyelitis of the upper surface of the clavicle. This appeared to involve the acromioclavicular articulation. The roentgenogram did not include the acromion process of the scapula. X-rays of the dorsal and cervical spines on two occasions showed no evidence of osteomyelitis.

The patient came to the Out-Patient Department for dressings three times a week and the wound over the shoulder gradually cleared up. A roentgenogram of the shoulder, taken on May 14, 1935, showed irregularity of the upper margin of the acromion with some new bone formation. No change in the distal end of the clavicle was noted at this time.

A sinus developed in the posterior midline in the region of the spine of the second thoracic vertebra. This was injected with an opaque mixture and stereoscopic roentgenograms showed a dilated sinus tract lying over the second thoracic vertebra and extending from right to left. The tract had no apparent connection with the vertebrae, and no bone pathology could be demonstrated in this region.

On June 22, 1935, the sinus was opened widely, curetted, and packed. A sequestrum, the shape of a vertebral spinous process and two centimeters long, was removed during this procedure.

The wound over the shoulder has completely healed and the wound in the posterior midline has filled with healthy granulations. At present, the prognosis for full recovery is excellent.

SUMMARY

An interesting sequela of this case of acute hematogenous osteomyelitis of the scapula, localized to the acromion process, was the development of a contiguous abscess over the upper dorsal vertebrae and the subsequent removal of a sequestrum, the shape of a vertebral spinous process. The latter was undiagnosed roentgenographically.

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A FORM OF BALANCED TRACTION

A Modification of Russell Traction

BY A. MARIANS, M.D., BROOKLYN, NEW YORK

*From the Orthopaedic Service *, Kings County Hospital, Brooklyn*

In the treatment of cases requiring traction to the lower extremity, it has been the author's practice to use Russell's method of producing traction. Since this method necessitates constant observation and adjustment, the author has devised the following modification which insures maintenance of the extremity in a fixed position.

As shown by Figure 1, traction is applied in the same manner as in the Russell method, except that a pulley is added at *A*, making five pulleys instead of four. The rope starts at a fixed point on the overhead bar and passes through pulleys *A*, *B*, *C*, *D*, and *E*, successively. The section of rope from the fixed point to pulley *B* forms a vertical line; the section of rope from pulleys *C* to *E* forms a horizontal line. The position of the femur is determined by the level at which pulleys *C* and *E* are

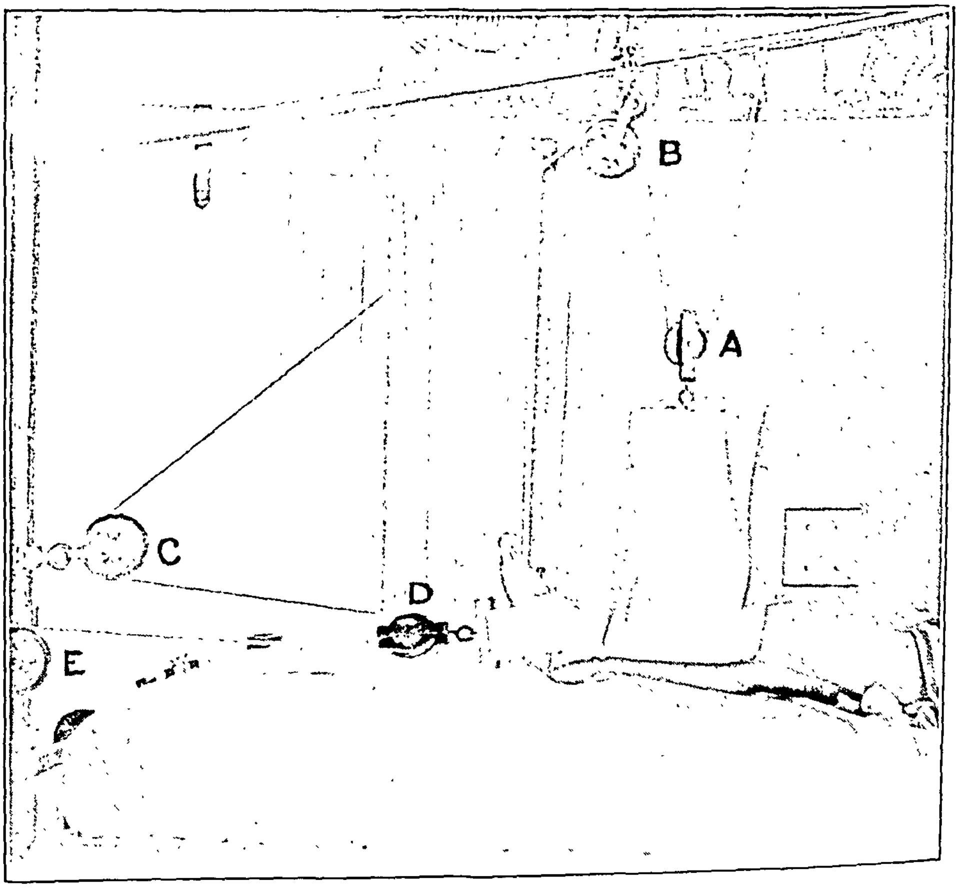

Fig. 1

* J. B. L'Episcopo, M.D., Director.

placed. The higher these are placed, the greater is the angle of hip flexion. The amount of weight necessary is determined by the weight of the extremity and the distance from the bed at which the leg is to be maintained. Enough weight is used to balance the extremity, seven pounds usually being sufficient for an adult.

Figure 2 illustrates the mechanism of producing traction by this method in the case of a fractured femur. The resultant of the equal forces *V* and *H* is *R 1*. However, the partial weight of the limb, *G*, is a variable, depending upon the height at which the limb is fixed. The resolution of *R 1* and *G* equals *R 2*. Furthermore, *R 2* is to a great extent neutralized by the resistance of the femur, *F*, producing the final resultant, *X*, whose force is problematic and whose direction is that of the distal portion of the femur. In cases where the fragments are pulled apart, *X* must be a positive quantity; where overriding persists, *X* is negative; where a perfect result is obtained, *X* is zero.

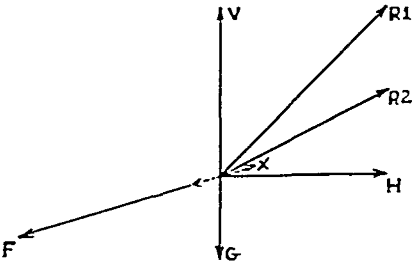

FIG. 2

This traction has been successfully applied to reduce fractured femora, flexion and adduction deformities of the hip, and flexion deformities of the knee, and to relieve referred pain in lumbosacral and sacro-iliac lesions.

A USEFUL AMPUTATION GUARD

BY FRANCIS M. FINDLAY, M.D., SANTA BARBARA, CALIFORNIA

It is very often difficult to retract the skin and muscles properly when performing a thigh amputation in an obese individual or in one with heavy thick muscles. Unless the soft tissues are adequately protected, the muscles will be traumatized by the saw and will interfere with cutting of the bone. The skin flaps must be firmly retracted or they will invert and contaminate the freshly cut surface of the wound. Trauma always results in tissue necrosis and provides a ready field for bacterial growth. With the large number of amputations now being done in older diabetics and arteriosclerotics, every precaution must be taken to avoid tissue necrosis and to prevent bacterial contamination of the wound. Meticulous attention to every detail of technique is essential if primary healing is to be the rule in every amputation stump.

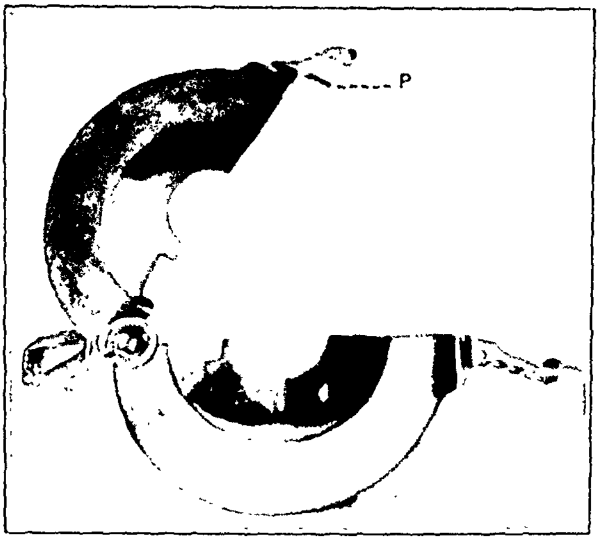

FIG. 1

Guard open, showing: holes for two bones; *P*, pin for locking handles which hold the disc together.

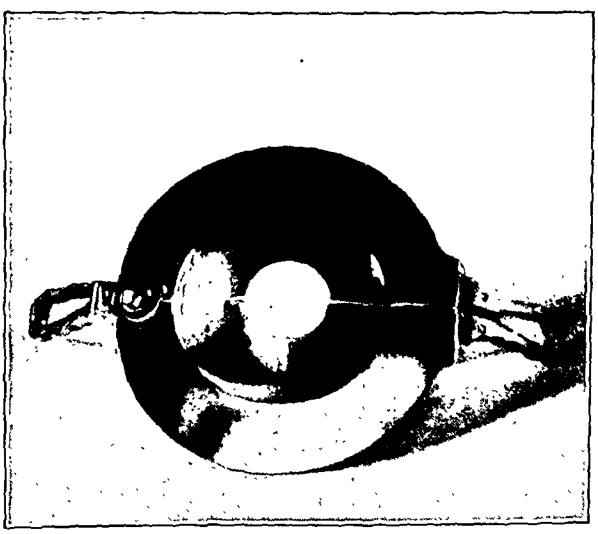

FIG. 2

Guard closed, showing handles locked in position.

Long strips of sterile gauze or towels, held by an assistant, are now commonly used to retract muscle flaps. This method is unsatisfactory, for the cloth frequently becomes caught in the teeth of the saw and the towels slip off at the critical moment, allowing the skin surface to come in contact with the muscles and bone. The guard illustrated in this paper is one that the author procured in Germany several years ago, and it has been found very useful. It is described in the hope that it may be of value to others.

This guard, a hinged metal disc with a slightly convex surface, is seven inches in

diameter and has two handles. The disc has two openings: the central opening is one and one-half inches in diameter and will readily admit the femur; the second opening can be used to advantage for amputations through the lower leg or forearm.

After the skin incision has been made, Allis clamps are applied to the skin flaps, which are held back while the deeper soft tissues are divided and the bone is exposed. The open disc is then applied and the blades are closed and locked about the femur. The assistant, while resting his forearms on either side of the thigh to steady the leg, exerts gentle traction upon the handles of the disc, which exposes the femur for the surgeon. The bone can now be severed without fear of catching gauze or muscle in the teeth of the saw. After the limb has been amputated, the guard is removed and the stump is closed in the usual manner.

A HIP BRACE

BY DAVID M. BOSWORTH, M.D., NEW YORK, N. Y.

In two recent cases of congenital dislocation of both hips in small children, open reduction was easily accomplished and was well maintained by the application of a double plaster hip spica. Following removal of the plaster spica after three months, one hip subluxated in each case. The apparent cause of the subluxation was a too rapid reduction of the position of marked abduction maintained following operation.

In order gradually to reduce the amount of abduction following removal of the plaster in such cases, a light brace (Fig. 1) has been devised and successfully used in a third case (Fig. 2). Gradual reduction of the abducted position can by secured by bending the distal cross bar upward. Meanwhile, inward pressure on the upper portion of the thighs can be obtained through the upper brace straps by gradually decreasing the size of the perineal loop at the same time that the distal cross bar is being bent upward.

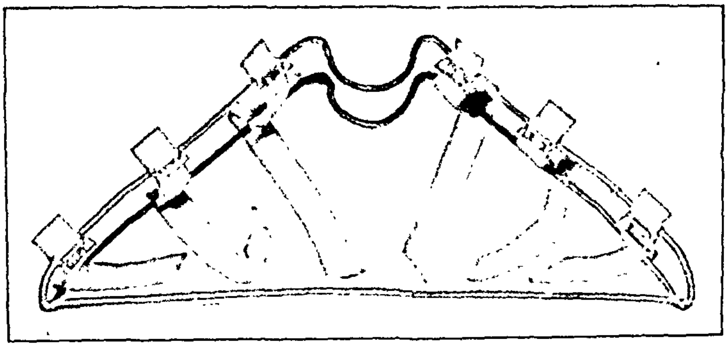

FIG. 1

FIG. 2

This brace embodies the principles laid down by Putti and Jaeger in the use of triangular braces and pads for closed reduction in congenital dislocation of the hip in much younger infants. The author believes that this simple and inexpen-

sive apparatus will aid in the gradual post-operative mobilization of the congenitally disslocated hip in both unilateral and bilateral cases, and will lessen the number of embarrassing cases in which the hip subluxates following removal of the plaster.

ADJUSTABLE SHOULDER STRAP FOR POSTOPERATIVE TORTICOLLIS CAST

BY FREMONT A. CHANDLER, M.D., CHICAGO, ILLINOIS

FIG. 1

Postoperative casts, applied to stabilize the head and neck following operations for the correction of torticollis, soon lose their efficiency as a means of stretching muscles and fasciae not divided surgically. In order to continue a corrective and stretching force, an adjustable padded sling is placed over the acromioclavicular area on the side which has been operated upon. The ends of the webbing strap are carried through holes in front and back of the cast and are buckled over the shoulder area. Increase of the tension of the sling depresses the shoulder, stretching all soft tissues on that side of the neck.

GOUT: AN UNUSUAL MANIFESTATION IN A STUMP

BY W. E. KENDALL, M.D., F.A.C.P., H. C. FORTNER, M.D., AND
S. K. LIVINGSTON, M.D., F.A.C.S., HINES, ILLINOIS

A reasonable search of the literature reveals no report referable to symptomatic gout in a stump. In the following case, a painful stump, due to pressure of minute uric-acid crystals against the nerve endings, had caused continuance of pain from 1932 to 1935. When systemic treatment for gout was instituted symptoms were relieved.

E. D., a white male, aged thirty-four, a farmer, was first admitted in 1930 for treatment of epithelioma of the left knee, with ulceration and partial fibrous ankylosis.

The patient had had the usual diseases of childhood. In 1920, a fracture of the left patella had been reduced by the open method. Thirty-one operations on the left knee had been performed during the period from 1920–1927. These operations had consisted of excision and cauterization of the ulcers. The family history was essentially negative.

Physical examination on March 13, 1930 was negative except for obesity and multiple cicatrices about the left knee with ulceration. On March 18, 1930, the ulcer on the lateral side of the knee was excised and the denuded area was covered by a pedicle skin graft, followed by irradiation for 792 millicurie hours. The patient was not cooperative and was not seen again until July 1932, at which time the lesion had increased in size. The left thigh was amputated and the stump healed satisfactorily. A prosthetic appliance was provided.

In September 1932, the patient returned, complaining of a painful stump. The left sciatic nerve was injected with alcohol on two occasions without relief; therefore, reampu-

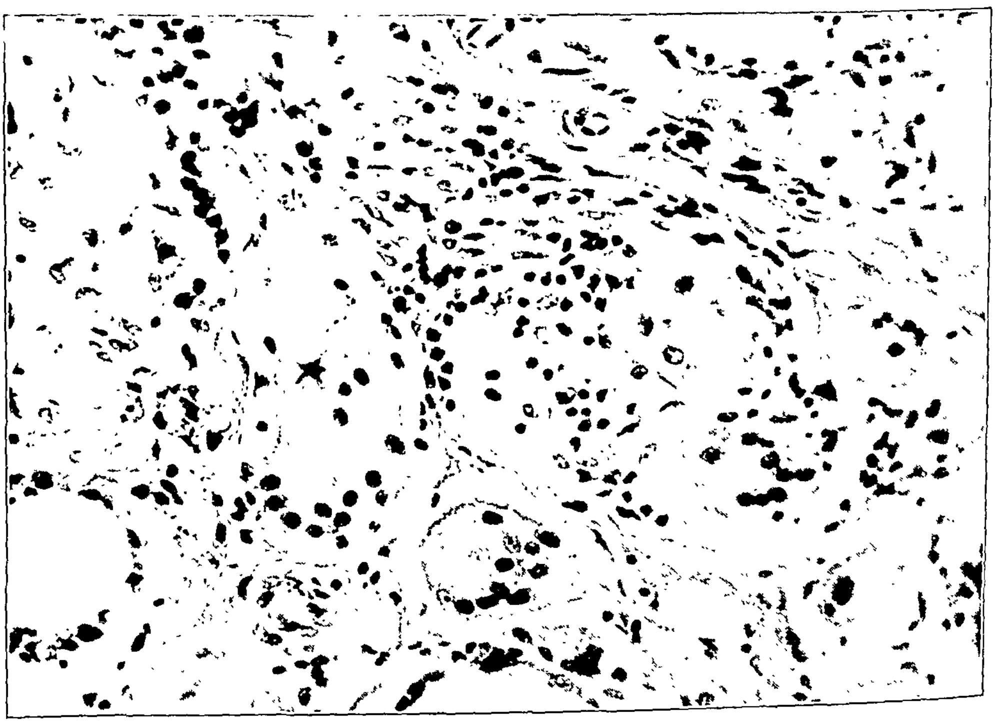

FIG. 1

Section from stump showing foreign-body reaction in the giant cells, within which uric-acid crystals are seen.

tation for exostoses and neuromata was done. The incision healed promptly and the patient was discharged in a few days, free from symptoms. Shortly after discharge, the stump again became so painful that the artificial limb could not be worn.

In May 1935, the patient was readmitted because of the painful stump. On examination, the amputation scar was found to be well healed. On the inner aspect of the scar, there was a nodule, small in size, but very tender. The nodule measured two centimeters in diameter and was firm. A diagnosis of recurrent neuroma of the left thigh was made. The mass was dissected and found to contain no nerve tissue.

Roentgenographic examination revealed a small island of abnormal density over the end of the stump, due to injection of a foreign substance or to calcified sequestra.

Analysis of the blood showed:

Red blood corpuscles—5,400,000
White blood corpuscles—10,000
Hemoglobin—95 per cent.
Uric acid—7.2 milligrams per 100 cubic centimeters.

The Wassermann and Kahn tests were negative.

Histological examination of the specimen from the stump (Slide 10,907), removed on May 13, 1935, showed an abundance of scar-tissue formation with heavy infiltration by round cells in places. In some areas, foreign-body reaction in the giant cells was evident. Within some of these cells, uric-acid crystals were seen. Most of these crystals lay wholly within or at the margin of the vacuoles. Uric-acid crystals are visible, as illustrated, within giant cells, whose walls protect the crystals from dissolution by the fixing process. Crystals without the giant cells could not be visualized, probably due to their destruction by fixation.

A diagnosis of gout was made and the usual medical treatment was prescribed, followed by relief of symptoms.

SUMMARY

In this unusual case of a painful stump, due to gout, the etiology was finally established by the following findings:

1. The blood uric acid was 7.2 milligrams per 100 cubic centimeters (twice the upper limit of normal);
2. Section from the stump revealed uric-acid crystals in giant cells;
3. Systemic treatment caused relief of symptoms.

COLON-BACILLUS OSTEOMYELITIS

BY MORRIS B. COOPERMAN, M.D., AND GOTTLIEB S. LEVENTHAL, M.D.,
PHILADELPHIA, PENNSYLVANIA

Osteomyelitis resulting from infection by colon bacillus is quite rare, judging from the fact that there are only eight cases reported in the literature. It is quite possible that others may have occurred but either have not been recognized or have not been recorded.

M. B., aged forty-nine, a veterinary surgeon, who had always been in good health, became ill on July 21, 1927, with symptoms and signs of trouble in the right upper quadrant of the abdomen. Roentgenograms on three occasions revealed an elevated and fixed right diaphragm. Bacillus coli and staphylococcus aureus were cultured from duodenal drainage. Febrile temperature subsided by lysis in eight days. On the twenty-eighth day of illness, the patient had an unexplainable rise of temperature. The fever declined gradually and the temperature was normal five and a half weeks after the onset of the illness. A roentgenogram, taken on August 25, 1927, revealed that the right diaphragm moved freely.

Early in September, signs and symptoms of an abscess developed on the lateral aspect of the left thigh at the junction of the lower and middle thirds. The white blood count was 15,000; polymorphonuclear leukocytes, 62. A large subperiosteal abscess was found and drained on September 14, 1927, but no culture of the pus was made. A roentgenogram revealed an extensive osteomyelitis, extending from below the greater trochanter to the lower third of the femur.

On October 7, the patient developed an abscess, containing a small quantity of pus in the left occipital region beneath the pericranium. The bone appeared sound and the wound healed. Culture was sterile.

One week later, the patient developed an abscess in the upper third of the left forearm. At operation, the periosteum of the ulna was found to be thickened, but there was no free pus. A smear, taken from the wound revealed the presence of a gram-negative bacillus in pure culture. A sinus in the left thigh persisted.

In November 1928, a pus pocket developed in the left thigh, which was drained. The sinus continued to drain for the next year, and, except for the development of small subperiosteal abscesses on the anterior aspect of both tibiae, which were opened by the family physician, the patient felt quite well.

In November 1929, another subperiosteal abscess in the left thigh was drained. A roentgenogram revealed the middle two-thirds of the shaft of the femur to be considerably increased in circumference, due to periosteal proliferation and new bone formation. The bone was unusually dense and sclerotic and there was no destructive lesion in the marrow cavity. A small subperiosteal abscess of the right tibia was incised and the wound healed in two months. Culture from the wound showed the presence of a staphylococcus aureus and a gram-negative bacillus identified as bacillus coli. The gallbladder failed to fill on cholecystography. The drainage of the left thigh persisted and, except for a superficial abscess of the left thigh and another of the left leg, the patient felt quite well for the next five years.

On January 1, 1935, the patient injured the left leg just below the knee. Pain and swelling followed and an incision was made by the family physician for a suspected abscess. Although some pus was evacuated, the swelling and pain became worse and the left knee became swollen and hot.

Blood examination showed:

White blood corpuscles—22,900 per cubic millimeter
Polymorphonuclear leukocytes — 89 per cent.
Urea nitrogen — 18 milligrams per 100 cubic centimeters
Blood sugar—161 milligrams per 100 cubic centimeters

A roentgenogram revealed an acute osteomyelitis of the upper end of the tibia.

At operation, there was a gush of canary-yellow pus from beneath the periosteum in the upper fifth of the tibia. The necrotic bone was osteotomized. On aspiration, pus was found in the knee, necessitating parapatellar incisions for drainage. Culture from the pus revealed the presence of a pure culture of bacillus coli.

The patient continued to become progressively worse, the osteomyelitis of the tibia progressed, and further saucerization of the left tibia was necessary. The incisions of the knee were also enlarged to permit better drainage.

On January 22, 1935, the patient developed pain and tenderness just below the right tibial tubercle. At operation, the periosteum was found to be thickened. Several drill holes were made into the bone, and, after a few moments, yellow pus welled up under considerable pressure. Culture from this wound showed the presence of bacillus coli in pure culture.

Blood culture, taken on January 23, 1935, also showed the presence of bacillus coli. The patient developed bronchopneumonia and marked tympanites. The blood sugar varied between 160 and 440 milligrams per 100 cubic centimeters and, on two occasions, there was sugar in the urine. The patient became very toxic and delirious, and died on January 27, 1935.

A very interesting feature of this case is the fact that all the foci of involvement except the last were subperiosteal, with marked periosteal new bone formation and no tendency to medullary involvement. The late Dr. John B. Deaver, who had treated this patient, felt that the osteomyelitis of the femur was secondary to a pathological gallbladder. Although the culture from the ulna was not identified beyond the gram-negative bacillus, in view of what subsequently followed, it is rather safe to assume that it was the colon bacillus. The supposition that the gastro-intestinal tract (gallbladder) could have been the original focus is supported by the fact that seven of the eight cases of colon-bacillus osteomyelitis reported in the literature came on during the course of, or convalescence from, typhoid fever. Wilensky is of the opinion that, except for direct infection, colon-bacillus osteomyelitis is secondary to a lesion in the gastro-intestinal tract through which the colon bacillus gains entrance into the blood stream. Satta cited a case of colon-bacillus osteomyelitis occurring in a compound fracture of the leg in which amputation was necessary in order to save the life of the patient. This is apparently the only reported case resulting from infection introduced from without. Satta noted that the pus was yellowish. Berg, Blumer, and Martina each reported a case with recovery from costal chondritis following typhoid. Charbonnel reported a case following dysentery, in which there was present greenish-yellow pus, marked periosteal thickening, and bone abscess. The patient recovered. Klemm and Arcoleo each reported a case following typhoid, from which both the colon and typhoid bacillus were cultured. Both patients died. Winslow reported a case

of osteomyelitis of the right femur in which the patient recovered with ankylosis of the knee. It is thus seen that cases in which there was secondary infection had a fatal termination, although an amputation was necessary to save the life of one patient without secondary infection.

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A TAUTENING BOLT FOR USE WITH KIRSCHNER WIRE WHEN PLASTER-OF-PARIS CASTS ARE USED IN THE TREATMENT OF FRACTURES

BY J. E. M. THOMSON, M.D., F.A.C.S., AND C. FRED FERCIOT, M.D.,
LINCOLN, NEBRASKA

To overcome the obvious disadvantage of having to incorporate a large bow in plaster for a long period of time, thus making the cast more cumbersome and necessitating the use of a large number of bows, we have devised a tautening bolt which may be used to replace the usual bow after twenty-four to forty-eight hours.

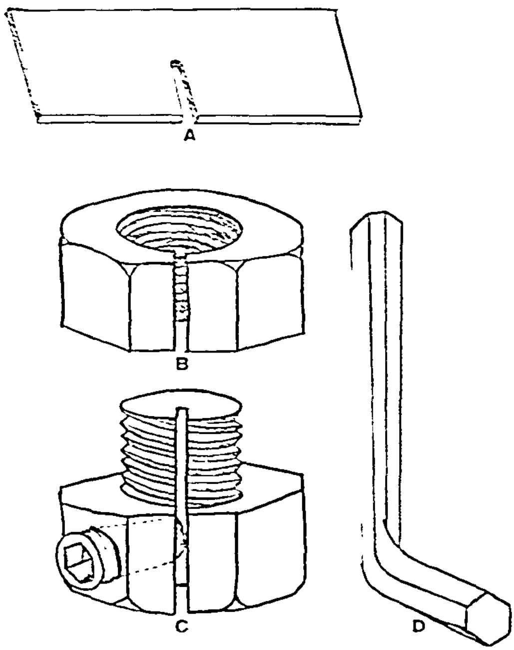

FIG. 1

Tautening-bolt assembly, showing: *A*, pressure plate; *B*, method of slotting; *C*, machinist's set screw; and *D*, wrench.

The tautening-bolt assembly consists of an ordinary three-eighths-inch bolt and nut, the bolt being, over-all, five-eighths of an inch in length. Both the bolt and nut are slotted by a wide saw cut to the longitudinal axis of the bolt. A case-hardened machinist's set screw is then placed in the head of the bolt in such a way that, when the slotted bolt is placed on the Kirschner wire, the set screw can be tightened effectively on it. A pressure plate, which is also slotted and about one inch in diameter, is used.

Technique of Application

The wire is drilled through the bone in the conventional man-

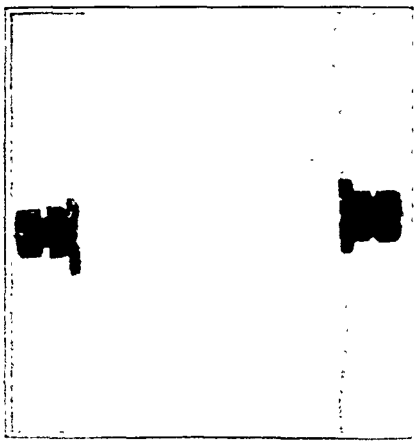

FIG. 2

Tautening bolt in place. The bow has been removed and the ends of the wire have been cut off.

ner and the tautening bow is applied. Suitable traction is applied by the use of the traction apparatus of a fracture table, and the reduction of the fractured fragments is accomplished. Anteroposterior and lateral molded plaster-of-Paris splints are applied and held in place by crêpe-paper bandage. Two four-inch squares of plaster-of-Paris splint are cut to their center and molded closely about the Kirschner wire, one on each side, and the whole is reenforced with several circular bandages. The patient is put to bed and swung under appropriate overhead frames. After forty-eight hours, or when the cast has thoroughly dried, slotted pressure plates and tautening bolts are slipped over the Kirschner wire close to the cast and the set screws are tightened firmly against the wire. By means of two thin wrenches, the nut of each bolt is turned against the pressure plates sufficiently to insure the tautness of the wire. The bow is removed and the ends of the wire are cut off, after which the whole may be covered by several turns of bandage if desired.

AN INEXPENSIVE PORTABLE THERAPEUTIC POOL

BY PHILIP PALEW, M.D., JACKSON HEIGHTS, LONG ISLAND, N. Y.

The many advantages of the underwater treatment in the after-care of patients who have had poliomyelitis need no elucidation at this time.

The lack of available space and, what is still more important, the lack of sufficient funds were responsible for the development of the tank which is described in this report. It has been in continuous use on the Orthopaedic Service of Dr. Arthur Krida at Bellevue Hospital for the past year, with very gratifying results.

A waterproof canvas tank—twenty-four inches deep, six feet long, and four feet wide—is suspended from a frame forty-three inches high. Standard faucets are incorporated into two opposite corners to permit rapid filling and emptying. The frame is constructed of interlocking galvanized pipe which can be taken apart easily. When the tank is not in use, it can be folded so that it occupies very little space. If sufficient space is available, the frame can be made at much less expense by joining the piping permanently with standard steam fittings.

An angulated Bradford frame is suspended from one edge of the frame and rests upon the bottom of the tank. The bottom of the tank is kept rigid by folding boards which are held underneath it by a folding steel framework. In the stationary tank the framework need not be so complicated.

Canvas straps, whose height can be altered, are slung across the head of the tank for the patients to rest their heads upon.

In filling the tank, a standard garden hose is connected to a combina-

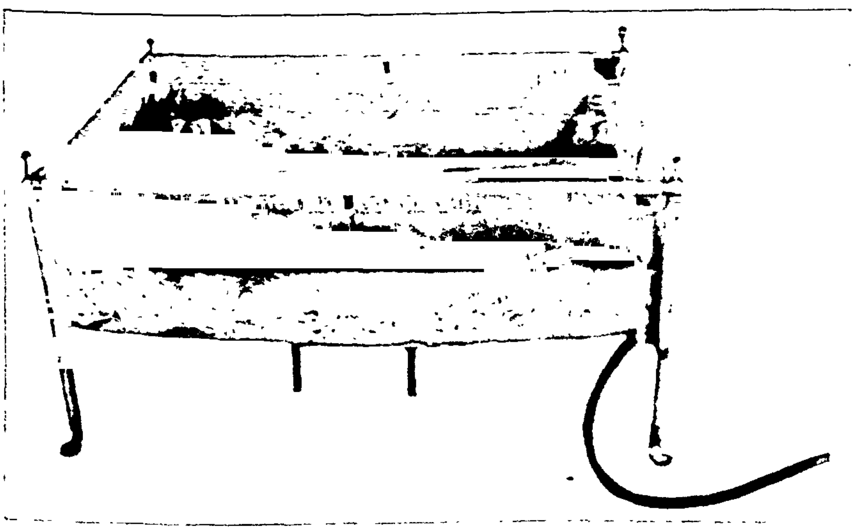

Fig. 1

tion hot and cold-water faucet and water of the desired temperature is permitted to flow into the tank. The water can be sterilized with chlorinated lime. The pool is easily washed with soap and water.

To make the tank more easily portable the legs are supplied with casters. Moving the tank while it is filled is not recommended because of the great weight of the water.

Another advantage of this pool is the fact that the attendant is not forced to soak in water for prolonged periods of time. Protected by a rubber apron, and without uncomfortably stooping over, the attendant can assist the patient in his muscular effort.

Besides its usefulness in the treatment of poliomyelitis, the underwater treatment has been found useful in the limbering up of stiff contracted joints which follow infectious arthritis or prolonged immobilization in casts after reduction of fractures or operative procedures.

News Notes

The orthopaedic world sincerely regrets the loss that has come to it through the death of **Mr. Ernest Muirhead Little.** Mr. Little was a prominent figure in the early days when the solution of the surgical problems was not so well determined, when the position of orthopaedic surgery was not so well established as it is today, and when the pioneers were endeavoring to find their places in the medical and surgical community. These were difficult times in the attempt to establish the recognition of the special departments. In addition to their professional accomplishments, the character and type of these men exerted an important influence in establishing mutual and cordial relations among the members of their community. Mr. Little was an active and prominent member. We may now pay tribute to him for the part which he played in the establishment of the privileges which we at this time enjoy. His sturdiness of character and good judgment helped to guide the work of those pioneers among whom he was prominent. In his passing, we have lost not only an orthopaedic surgeon, but a kindly gentleman of the old school.

Readers of *The Journal* will be interested to know that "*Zeitschrift für Orthopädie und Ihre Grenzgebiete*" is the new name of the official publication of the **Deutsche orthopädische Gesellschaft,** formerly known as the "*Zeitschrift für Orthopädische Chirurgie Einschliesslich der Heilgymnastik und Massage*". This change became effective with 64. Band, 1. Heft, 1935.

The **American Academy of Orthopaedic Surgeons** will hold its Fourth Annual Convention on January 13, 14, 15, and 16, 1936, at the Hotel Jefferson, St. Louis, Missouri. A large attendance is expected.

Sessions will be held on three mornings and three afternoons. On Monday afternoon there will be a Symposium on Bone Tumors, and on Wednesday afternoon a Symposium on Fractures and Dislocations in and around the Elbow Joint. At each morning session and at the Tuesday afternoon session four twenty-minute papers will be presented, with four five-minute discussions of each paper.

The program has been so planned that at each session will be presented papers from one section of the country, while the discussors for these papers have been selected so as to represent the views of other sections of the country on the essayist's subject. Monday morning's session will be presented by men from the Pacific Coast; Tuesday morning by men of the Middle West; Tuesday afternoon by men from the East Coast; Wednesday morning by members from the South and Southwest.

Each morning session will start at 9:30 o'clock and end at 12:30; each afternoon session will start at 2:00 o'clock and end at 4:30. This will give adequate time each day for the inspection of the Scientific and Commercial exhibits, which will be of unusual interest.

During the morning and afternoon of January 16, an unusually well planned program of diagnostic and operative clinics will be conducted by the leading orthopaedic surgeons of St. Louis.

The American Society for the Study of Arthritis held its Seventh Annual Meeting on December 12, 13, and 14, in New York City. The sessions were held in Le Perroquet Suite of The Waldorf-Astoria. A most interesting program had been prepared, including the informal presentation of papers at the afternoon sessions on Thursday and Friday, round-table discussions of arthritic problems on Thursday and Friday mornings, and the annual business meeting of the Society on Saturday morning. On Thursday evening the annual open meeting of the Society was held at the New York Academy of Medicine, and

papers were presented by Dr. Reginald Burbank, New York, N. Y., Dr. Loring T. Swaim, Boston, Massachusetts, and Dr. Martin E. Rehfuss, Philadelphia, Pennsylvania.

The Thirtieth Congress of the **Deutsche orthopädische Gesellschaft** was held in Köln on September 2, 3, and 4, under the presidency of *Prof. M. Hackenbroch.*

The principal subjects considered at the Congress on the different days were the Interrelation of Structure and Function, Orthopaedic Surgery and Its Relation to Posture, Development of the Body, and Degenerative Changes of Occupation and Age. A number of the members presented papers on each of these subjects, and this presentation was followed by general discussion by the members.

On the third day, the subjects of Arthrodesis and Tenodesis and Coxa Valga were presented and discussed. Numerous papers on other matters of orthopaedic interest were also presented by various members and guests.

On the evening of Monday, September 2, there were demonstrations and illustrations by lantern slides and pictures along the lines of the subjects which had been discussed, as well as on various other subjects.

The 1936 Congress will be held in Königsberg, under the presidency of Prof. Dr. L. Kreuz.

The Congress of the **Czechoslovakian and Jugoslavian Orthopaedic Societies** was held at Brno, September 26, 27, and 28, under the presidency of Prof. Dr. B. Frejka.

The mornings of the first two days were devoted to demonstrations and operations. Among the operations performed at this time were osteotomy for genu valgum, correction of torticollis, resectio sub talo, astragalectomy, and fusion of the spine both for tuberculosis and for lumbosacral arthritis. On the afternoon of September 26, there was a dry clinic, with demonstrations of postoperative cases of these conditions, showing the treatment necessary, particularly in cases of lumbosacral arthritis in which an osteosynthesis had been performed.

The academic program of the Congress was opened on the afternoon of September 27 by the President. The principal subject was Low-Back Pain. Dr. Gradojević, as the first speaker, presented a paper giving a summary of the different causes of pain in the lumbar region and emphasizing the rôle played by static defects in these conditions. Dr. Frejka drew attention to the frequency with which these pains occur in those engaged in heavy work. The majority are not from toxic infection, nor are they of the character associated with degenerative changes in the spine. Injury to lateral and articular processes and spondylolisthesis frequently play a part. Dr. Jaroš gave a comprehensive survey of the methods of diagnosing pain in this region, particularly with reference to the problem of industrial insurance.

Prof. Zahradníček demonstrated a new method of treatment for spondylolisthesis, in which a bone graft from the outer side of the iliac bone is introduced so as to give support to the body of the fifth lumbar vertebra. During the remainder of the session, papers on various subjects having particular orthopaedic interest were presented by a large number of the members.

The Congress then closed with a general assembly of the members of the *Czechoslovakian Orthopaedic Society.* At this meeting, Prof. Dr. Mikula of Bratislava was elected President and it was voted that the principal subject of the next Congress should be "Inflammation of the Joints". Prof. Frejka was elected as the principal speaker on the subject of "Conservative Treatment for Inflammation of the Joints". Members of the Jugoslavian Society undertook the report on gonorrhoeal inflammation and Prof. Mikula a report on arthroplasties. Prof. Zahradníček is to be the speaker on the subject "Treatment of Fracture of the Neck of the Femur".

The next Congress is to be held at Bratislava on June 27, 28, and 29, 1936.

Current Literature

Mechanics of Normal and Pathological Locomotion in Man. By Arthur Steindler, M.D., F.A.C.S. Springfield, Illinois, Charles C. Thomas, 1935. $8.00.

The book deals with an immensely complicated set of phenomena the study of which has interested scientifically minded students from very early times. The author labors under no delusions as to the difficulties in deducing something that is of practical, clinical importance from a mass of observations based upon studies in physics, mathematics, physiology, biochemistry, and mechanics.

In Part I, the approach to present-day kinesiological concepts is traced interestingly from the historical standpoint, leading up to a consideration of the relations of the science of human motion to other allied sciences. That the study is not a purely theoretical one is supported by the fact that there are many close analogies between what the mechanical engineer has determined in respect to strains and stresses when applied to inert materials and what the kinesiologist has ascertained. The importance of knowing of how much value skillful motion is as compared with unskillful motion is very great. The application of the laws of mechanics to human motion is fully discussed, the body being regarded as an inert unit, but in life it must be looked upon as an articulated, mechanical unit; in this respect, the only possible motion is rotary,—one part moving against another. This calls for a readjustment of the action of gravital laws for the maintenance of body equilibrium, a much more complicated mechanism than is required in the case of inert bodies. Suffice it to say that a formula has been worked out by which the resistance of a human limb to rotary motion may be accurately expressed in mathematical terms. The application of this formula makes it possible to appreciate certain peculiarities of the human gait and many other manifestations of human activity, such as running, jumping, and the like. After a consideration of the many graphic methods of recording the planes of the centers of gravity in the various joints and a discussion of the physical properties of bone, the author proceeds to a discussion of the dynamics of muscle action in response to which provision is made for shifting the axes of the muscles that are almost invariably arranged in parallelism with the axes of the parts of the skeleton which they are to move, so that the angle of the application of the force which they are to exert may be increased. Power and speed are recognized as distinguishing properties of muscles in different parts of the body where these qualities are particularly called for in the performance of their functions. The author then discusses the elasticity and contractility of muscle fibers and the tensile strength of tendons in their relation to the determination of the location of ruptures of these structures under adverse conditions. The first section closes with three chapters on "Electrophysical Analysis of Muscle Action", "The Coordination of Skeletal Muscle Action", in which simple lever action as a problem in mechanics must needs be modified in view of the manner in which such a simple mechanical principle undergoes modification when working against other joints, and "Fatigue and Recovery".

In Part II, specific application of the mechanical principles enunciated in the previous section is made to the vertebral column, the thorax and pelvis, the shoulder girdle, and the elbow and hand, in both normal and pathological conditions. The summation of all this is presented in an analysis of the activities of the baseball pitcher, the shot putter, the discus thrower, the broad jumper, and the track man, and finally in a study of the human gait. The studies are invaluable for the teacher of physical culture, as well as for the orthopaedic surgeon, the solution of whose problems will be made infinitely clearer when the reasons for normal behavior are understood. The author has succeeded admirably in translating abstruse and extremely technical mechanical data into practical application, understandable "to the man in the street".

DIE ORTHOPÄDISCHE WELTLITERATUR. Edited by Prof. Dr. August Blencke and Prof. Dr. Hermann Gocht. I. Band. Stuttgart, Ferdinand Enke, 1936. 87 marks.

This is the first of two volumes and is composed of references to works on orthopaedic surgery gathered from all over the world. This enormous piece of work has been issued under the direction of Prof. Dr. August Blencke, of Magdeburg, and Prof. Dr. Hermann Gocht, of Berlin. The need of such a volume was suggested by the compilation of world literature, published by Hoffa and Blencke in 1905. Since that time, references to the literature on orthopaedic surgery and many of its allied or associated departments in medicine and surgery have not been collected and made available to the medical world. The present volume presents the literature on this subject which has appeared throughout the world between 1905 and 1930. The compilation of this bibliography represents an immense amount of work on the part of the editors, their collaborators, and the publishers. The task was made more difficult by the fact that in some countries many of the allied subjects were grouped under orthopaedic surgery.

The book is very conveniently arranged, the references under each subject being indexed alphabetically according to the name of the author. Easy access to the literature during the last thirty years is afforded to orthopaedic surgeons, general surgeons, pediatricians, nerve specialists, anatomists, and pathologists. In selecting the material, the editors have taken the works which are of the most significance to orthopaedic surgery. Many subjects are not included, such as fresh fractures and dislocations, etc., but such conditions as malunited and ununited fractures and pseudarthroses, sequelae of bone inflammation, are included when they have a definite orthopaedic bearing.

The material is divided into six main headings:

1. The care of cripples, war injuries, general orthopaedic subjects, and works associated with these on anatomy, physiology, pathology, and diagnosis;
2. Orthopaedic apparatus, bandaging, and apparatus used in recumbency;
3. Closed and open surgery, including closed methods of treating deformities, operations on the soft parts, operations on the bones and joints, amputations, and artificial limbs;
4. Massage and gymnastics, including physiotherapy and exercises used in the treatment of orthopaedic conditions;
5. Congenital diseases and deformities.
6. Acquired diseases and deformities, including diseases of alteration of the skin, tendons and muscles; pathological changes in the central nervous system; infantile paralysis; injury to the peripheral nerves; diseases of bones and joints; diseases and deformities following injury to the bones; diseases and deformities subsequent to injury of the joints; rheumatism; bone and joint tuberculosis; rickets; and osteomalacia.

This first volume will be welcomed by all who have occasion to investigate the work which has been done and it will be indispensable to libraries and institutions.

ANATOMIA DELLA LUSSAZIONE CONGENITA DELL'ANCA (Anatomy of Congenital Dislocation of the Hip). By Prof. Dr. Vittorio Putti. Bologna, Licinio Cappelli, 1935. 300 lire.

In the first part of his newest publication, Prof. Putti gives a minute description of the anatomical findings in congenital dislocation of the hip, including the relations of muscles, nerves, the capsule, the secondary socket, the femoral epiphysis, and the neck of the femur. He emphasizes particularly the changes in the anatomical arrangement of the glutei and the iliopsoas, and the relation of the latter to the capsular isthmus. Then follows a description of the cotyloid and femoral insertions of the capsule, the round ligament, and the glenoid limbus. The latter's relation to the reduced head is of particular interest. The descriptions of the secondary socket and the femoral epiphysis and its separation from the cotyloid contour (*lateralizzazione*) in subluxations are classic. So also is the paragraph on anteversion, evaluating its pathological significance, etc. Especially valuable is the description of a specimen of a hip, six months after reduction, as it gives a clear insight into the processes of initial reconstruction. The richness of the proliferating, well vascularized connective tissue in all parts of the articulation is noted;

at the same time, this specimen illustrates the plastic adaptation of the newly reduced articulation to the new mechanical condition.

Then follow most excellent roentgenograms and mechanical drawings of the normal hip, the musculature of the dislocated hip, and the subluxated and dislocated hip in all stages, with splendid anatomical specimens showing every detail of muscular, capsular, and skeletal changes. There are nine observations on pathological specimens of unreduced hips and of the bloodless reduction. The technique of open reduction is beautifully illustrated. Variations of the acetabular inclination and the predislocation stage are demonstrated by roentgenograms. Also shown by excellent roentgenograms are subluxation and its evolution, infantile and juvenile dislocation, and inveterate dislocation. In the roentgenographic section, probably the most fascinating chapter is that on reconstruction and healing of the reduced hip; this chapter contains some rare instances of perfect anatomical restitution.

Last, but certainly not least, is a section on the postreduction pathology, showing degenerative changes in the epiphysis, necrosis, fragmentation, deformations of the head, etc.; and a most interesting series of pseudocongenital dislocations,—poliomyelitic, traumatic, pyogenic.

To say that this book is the best that has yet appeared on the subject is hardly doing it justice. It is a classic in every sense; a monument of most elaborate and painstaking study and a wonderful work of art.

Localized Rarefying Conditions of Bone as Exemplified by Legg-Perthes' Disease, Osgood-Schlatter's Disease, Kümmell's Disease and Related Conditions. By E. S. J. King, M.D., D. Sc., M.S. (Melb.), F.R.C.S. (Eng.), F.R.A.C.S. London, Edward Arnold & Co., 1935. 35 shillings. Baltimore, William Wood & Co., 1935. $7.50.

It is fortunate that we have at last in book form an exhaustive presentation of the diseases of the growth centers. The material contained in this book represents a tremendous task because of the necessity of reviewing a bibliography of almost 1,000 articles. The author is generous in quoting from the opinions of others, adding those of his own gathered from an exhaustive study of the subject. The various subjects are illustrated with well selected prints, the reproductions of which are good. A very complete bibliography is appended to each chapter.

The early chapters are concerned with a consideration of normal bone structure, development, chemical composition, physiology, and anatomy. Factors producing rarefaction of bone and excessive calcification are considered,—generalized diseases of growing bone, such as rickets, infantile scurvy, and syphilitic osteochondritis, as well as certain post-traumatic rarefying diseases occurring in adult bone.

The general term "osteochondritis juvenilis" is used to indicate the process in the various growth centers. The primary and secondary centers of ossification are enumerated. As the author indicates, the term "osteochondritis" is used with certain reservations, since pathological study of the disease has revealed no evidence of true inflammation.

During the last three decades, a disorder of the centers of ossification of a number of bones of the human skeleton has been described. It presents a characteristic roentgenographic appearance in the newly formed bone and it has been recognized by means of roentgenograms in all the various sites of occurrence.

As the author states, the investigation of the literature relating to this condition reveals a confusion and plethora of terminology that is almost unrivalled in medical literature. Further, it discloses a wealth of hypotheses, embracing many views from simple deductions based on experimental or clinical inquiry to purely philosophical considerations lacking a basis of observation, and a rapidly extending bibliography including many papers which add little or nothing to our knowledge. On the other hand, a large amount of accurate clinical knowledge has accumulated, and information concerning [illegible] pathological changes has been obtained from the study of material removed at operation

As a whole, the book is well balanced and informative. The author is to be commended for the thoroughness and fairness with which he has presented the subject. The book should be read by all those interested in diseases of bone.

Der Schenkelhalsbruch: ein mechanisches Problem (Fracture of the Neck of the Femur: a Mechanical Problem). By Dr. Friedrick Pauwels. Beilageheft zur Zeitschrift für Orthopädische Chirurgie, LXIII, 1935. Stuttgart, Ferdinand Enke, 1935. 15 marks.

The late Alfred Schanz, to whom this important monograph is dedicated, studied the mechanics of the high and low subtrochanteric osteotomies. His simple explanation and dramatic proof of their effectiveness in reducing disability at the hip have stimulated the use and further investigation of these measures. One of his pupils now offers a most exhaustive and significant study of the problem of fractures of the femoral neck.

Two-thirds of the volume deals with the clinical aspects. The mechanical forces which influence callus formation are considered in general and with specific relation to the femoral neck. The effects of stress and strain are clearly differentiated. The most important forces which operate are shear and pressure. If the plane of the fracture is vertical, the shear is maximal. As the fracture nears the horizontal, the direct pressure on the fragments becomes greater and the shearing force less. The elaboration of this fact leads to the classification of femoral-neck fractures as those in which (1) the shear is negligible (valgus position), (2) the pressure component is insignificant as compared to the shear, and (3) the line of force on the head passes medial to any point of contact of the fractured surfaces, so that there is not only a shearing but also a tilting force. The latter results in strain rather than stress on most of the forming callus.

The obvious relation of these observations to prognosis and treatment is followed out with great exactitude.

Various methods of treatment of fresh and ununited fractures are reviewed and dispassionately evaluated as a preliminary to the recommendation of high subtrochanteric osteotomy (renamed *Reklination*) as the ideal treatment of pseudarthrosis. The mechanical principles are illustrated by simple diagrams and photographs of working models. Case records and characteristic reproductions of roentgenograms are accompanied by outline diagrams in which forces are analyzed.

The last fifty pages are so highly mathematical that they will be skipped by most medical readers. Several formulae are derived which explain in a striking manner the progress of healing or non-union of the various types of fractures of the femoral neck.

In this period of argument over the efficacy of this screw or that nail, it is refreshing to get back to fundamentals of treatment. No contribution to our understanding of the "Unsolved Fracture" is more significant than the work of Dr. Pauwels, which is here so completely presented.

Russell A. Hibbs, Pioneer in Orthopedic Surgery. By George M. Goodwin. New York, Columbia University Press, 1935. $2.00.

From those who were privileged to know Russell Hibbs, this appreciation of him as an individual and as a surgeon will receive a hearty welcome. Very properly, Mr. Goodwin has emphasized Hibbs's most outstanding quality—his personality. The charm of a southern gentleman made a friend of whomsoever he met, with but few exceptions. This charm, coupled with his native ability as a technician and his deserved popularity among those who worked with him, enabled him to achieve the prominent position which he gained as an orthopaedic surgeon. His realization of the difficulties of providing sufficient hospitalization facilities for those who needed them and were too poor to pay for them supplied the incentive for finding a method of treatment that would shorten the duration of hospital care for this class of patients and by so doing bring a larger number within reach of the service they needed. To have done this was a major surgical and economic contribution. Such a record of accomplishment by an unaccredited young

man who made his way, at first on sheer personality, to an enviable position in a great city, where competition was keen, should be made available for the encouragement of others.

ERBBIOLOGIE DER ANGEBORENEN KÖRPERFEHLER (Biological Inheritance of Congenital Deformities). By Prof. Dr. Max Lange. Stuttgart, Ferdinand Enke, 1935. 9.60 marks.

In this handbook, the author estimates that there are in Germany 100,000 persons with congenital bodily deformities, the care of whom the State should undertake. The State demands, however, that the deformed group be prevented from multiplying. The author agrees with Rüdin that, by curing many of these patients, modern orthopaedic surgery often removes an obstacle to marriage. Progressively the burden of the State is augmented and there is developed an increased percentage of congenitally deformed patients.

The book deals with the problems connected with the law for sterilization, passed on July 14, 1933. The author states that to come under the law a deformity must be severe and the probability of inheritance must be high. The correctability of a lesion is not a decisive factor.

The author of this book, in company with the authors of several other recent publications, wrestles bravely with the medico-legal judgments involved. He describes the conditions which are connected with this problem and discusses some of the special deformities which come within the domain of orthopaedic surgery, such as club-foot, club-hand, and congenital pes cavus. He then considers systematically the various orthopaedic deformities and their legal fates,—a list worthy of serious study.

To the average physician, if eugenically minded, the enormous problems involved in the individual decisions appear almost impossible of solution, considering our present knowledge, but the book is distinctly interesting in relation to its medico-legal aspects. The author, however, is obliged to help the local medical board reach a definite conclusion in each case and usually manages to be quite explicit, although frequently not quite medically convincing.

BALANCE SKILLS IN PHYSICAL EDUCATION. By Charles Leroy Lowman, M.D., F.A.C.S. Ann Arbor, Edwards Brothers, Inc., 1935. $1.60.

The author of this work elaborates on the necessity of more accurate coordination in the use of physical exercises, which is usually not sufficiently emphasized. In the development of his system, Dr. Lowman has given full recognition to this need of coordination and has employed it in his own individual work for many years. In this book he explains the system of balance exercises which he has used.

The first part of the book is devoted to a consideration of the anatomical, physiological, and neuromuscular factors, and the various theories which have been offered in explanation of the mechanism of balance.

A portion of the book is then given to an exposition of the use of the tilted board in developing balance control and in adding to coordination, and the effects of this training on the different parts and structures of the body. Dr. Lowman has studied the question of the physical stress of malposture in its relation to the added strain from imbalance. He then makes a number of suggestions in regard to the use of the tilted board in the various exercises and its employment by field workers. He gives also the contra-indications for its use in certain conditions and diseases and describes the various exercises which are employed to correct the malposture and the imbalance, with prescriptions for their special use.

The text is supplemented by a number of excellent illustrations, and, for all who are interested in the use and effects of physical training, especially as applied to certain [illegible] conditions, this book will be found to contain many helpful suggestions and will be of very practical value.

Die Verletzungen der Wirbelsäule (Injuries of the Spinal Column). By Prof. Dr. V. Schmieden and Dr. L. Mahler. (*In Vorträge aus der praktischen Chirurgie, 2. Heft, Herausgegeben von Erich Lexer.*) Stuttgart, Ferdinand Enke, 1935. 1.60 marks.

The authors have evidently been impressed by the astounding increase during recent years of injuries to the spinal column. Because of the diversity of these injuries, many new problems have arisen, necessitating further study.

The authors have presented this subject from many points of view and have considered practically all the conditions which result from injuries to the spinal column and its appendages. They find that the largest number of injuries occur in the thoracic and lumbar regions, particularly at their junction. Two-thirds of the injuries involve the first lumbar vertebra; next in frequency are injuries to the twelfth dorsal vertebra; and, third, injuries to the second lumbar vertebra. Hospitalization is most advisable, since it lessens the unfavorable sequelae.

From the standpoint of treatment, fractures are divided into four groups: (1) compression fractures of the vertebral body; (2) diagonal fractures, with anterior wedge-shaped fragmentation; (3) partial-dislocation fractures; and (4) complete-dislocation fractures, with absolute dissolution of continuity.

In compression and diagonal fractures, the posterior longitudinal ligament in the canal remains intact, which is a particularly important feature, inasmuch as it protects the cord anteriorly. In the types of dislocation-fractures considered under the last two headings, tearing of this ligament occurs and the cord is usually crushed. In the treatment of compression and diagonal fractures, the authors recommend immobilization by recumbency in plaster. Rarely does consolidation fail to occur, but in that event operation may be necessary to overcome this static insufficiency.

The problem of cord injuries and their treatment is then discussed in detail; in general, the authors take a conservative attitude on this question. Lumbar puncture is frequently an aid in determining the condition of the cord and the myelograph is also of value in early diagnosis, as it helps to establish the prognosis and to indicate the feasibility of operation when paralysis exists.

The authors then consider the various types of injuries which are found in this region, including and discussing in order fractures of the transverse and spinous processes, fractures of the sacrum, fractures of the coccyx, and dislocations, which are too often regarded as sprains, but which are very often accompanied by fractures, particularly in the dorsal region. The authors then take up the question of violence to the spinal column without actual fracture, but with damage to the ligamentous and muscular apparatus. They discuss spondylolisthesis, as well as spondylitis deformans and the rôle which it may play in injuries of the spine. The question of gunshot and stab wounds is also considered.

This subject of spinal injuries presents many new factors and, as a decidedly controversial field, it offers many opportunities for expression. Unfortunately, the spine still remains the dumping-ground for vague and indefinite diagnoses which are the source of many doubtful undertakings and much keen debate. Out of all the chaos there are constantly developing many valuable observations which may be of benefit to the physician in the treatment of his patients.

Individual Exercises. Selected Exercises for Individual Conditions. By George T. Stafford, M.S., Harry B. DeCook, M.A., and Joseph L. Picard, M.S. New York, A. S. Barnes and Company, Incorporated, 1935. $1.00.

There is a definite need for a guide in the selection and the carrying out of special exercises for individual cases, which may be used by physicians, teachers, and physical trainers. The three authors of this book have had a great deal of experience in this department of physical training, and have drawn on their practical knowledge in compiling a series of exercises which may be used in dealing with the various malconditions which constantly need attention.

The book contains excellent advice in regard to the general subject of exercises and the purposes for which they are designed, and will be distinctly valuable to those who desire help on this problem. The authors discuss the part which exercises play in maintaining health and in preventing certain conditions. Specific exercises are explained and illustrated by "stick men" drawings, their purposes are indicated, and the factors influencing their choice for use in the simpler conditions are given. The authors state very distinctly that these exercises should not be given except by advice of a physician. After such advice is received, a selection can be made by referring to the grouping which is given in this book.

The information in this book is particularly useful to teachers who are obliged to supervise the exercises of children and to those physicians who have not had opportunity to become familiar with the exercises for the special conditions for which they may be called upon to prescribe. The well equipped physical trainer would find this book interesting, but he should already be familiar with most of the material which it contains.

ORTHOPÄDIE VOR 100 JAHREN. DIE ORTHOPÄDISCHEN INSTITUTE ALS VORLÄUFER DER HEUTIGEN KRÜPPELHEIME (Orthopaedic Surgery 100 Years Ago. The Orthopaedic Institution as a Predecessor of the Present-Day Home for Crippled Children). By Prof. Dr. B. Valentin. Stuttgart, Ferdinand Enke, 1935. 1.80 marks.

This readable description of the early orthopaedic institutions of Germany and France is illustrated by several cuts of men, buildings, and apparatus. It deals chiefly with the period when club feet and scoliosis were the only deformities treated. The leaflet furnishes chiefly a background for understanding the government organization for the care of the crippled in Germany. It is interesting reading and valuable history.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Anales (Valencia), II, Núms. 16–18, 1935.
Anales de Pediatría (Facultad de Medicina de Barcelona), II, Núms. 18, 19, 1935.
Archivio di Chirurgia Infantile, I, Fasc. 4, 1935
Cleveland Clinic Quarterly, II, No. 4, 1935.
Current Medicine, II, No. 12, 1935.
The Mississippi Doctor, XIII, No. 6, 1935.

VERTEBRA PLANA-CALVÉ. Halfdan Sundt. *Acta Chirurg. Scandinavica*, LXXVI, 501, 1935.

The author reports a case which he has observed for one year, and describes a case from the literature which has just been followed up after a lapse of eleven years. Flattening progressed in spite of a plaster jacket or bed rest. Only slight regeneration of the vertebral body was noted. The subject is thoroughly discussed and a critical survey of the literature is included.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

TUBERKULOSE IN DEN DIAPHYSEN DER LANGEN ROHRENKNOCHEN (Tuberculosis of the Diaphysis of the Long Bones). Ragnar Magnusson. *Acta Orthop. Scandinavica*, VI, 93, 1935.

Thirty cases of diaphyseal tuberculosis in twenty-three patients are critically analyzed and the findings tabulated. They comprise 1.08 per cent. of the cases of bone tuberculosis in the *Apelviken Kustsanatoriet* over a period of six years. The lesions are designated as metaphyseal, periosteal, osseous, and osteomyelitic, but the distinction is not always clear cut. The statistics in regard to the localization of foci are as follows: femur, in nine cases; tibia, in eight; radius, in five; ulna, in four; fibula, in three; and humerus, in one.

Metaphyseal lesions were usually associated with joint symptoms, which were relieved by early operation in four cases and by conservative treatment in two. The symptoms were obviously toxic in nature. Early operation is advised if there is [illegible] evidence of progress of the lesion.

Eight cases of periosteal tuberculosis were treated conservatively. Five cases of osteitis and seven of osteomyelitis completed the list. Subperiosteal resection was performed in three of the latter cases, with satisfactory regeneration of bone from the periosteum.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

NECROSIS CAPITIS FEMORIS. Kurt Stenport. *Acta Orthop. Scandinavica*, VI, 127, 1935.

The closed reduction of slipped femoral epiphyses has led to necrosis of the head and even bony ankylosis in so many cases in Swedish hospitals that this treatment is condemned. Instead, for the mild recent cases, the writer suggests simple traction with internal rotation for three months, and then crutches for three months more. For the cases in which there is considerable displacement, operative correction is recommended.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

BESTEHT EIN ZUSAMMENHANG ZWISCHEN HALLUX RIGIDUS UND DEN OSSALEN ASEPTISCHEN NEKROSEN (Are Hallux Rigidus and the Aseptic Bone Necroses Related?). S. Ribbing. *Acta Orthop. Scandinavica*, VI, 138, 1935.

In support of the theory that hallux rigidus is caused primarily by aseptic bone necrosis, a detailed study is made of a family of seventeen, who showed multiple bone lesions of the aseptic-necrosis type. Four of this number had contractures of the great toe joint with suggestive roentgenographic findings.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

VERTEBRA PLANA CALVÉ. Nils Lindström. *Acta Orthop. Scandinavica*, VI, 208, 1935.

A case of true vertebra plana of Calvé is followed for seven years, after onset at the age of four years.

The second lumbar vertebra gradually became flat and dense during the first year. Then it gradually regenerated to about three-fourths of its normal height and normal bone structure. The case satisfies Calvé's postulates:

1. One vertebra only is flattened;
2. The intervertebral spaces are intact;
3. There is even an increase in thickness of the cartilage;
4. The vertebral rest yields a dense shadow on x-ray;
5. Regeneration takes place.

The writer is critical of the inclusion of several of the twenty-four cases in the literature which are classified as Calvé's disease.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

EL TRATAMIENTO DEL PIE BOT VARO EQUINO CONGÉNITO (The Treatment of Congenital Inverted Club-Foot). Barboza Vianna. *Cir. Ortop. y Traumatol.*, III, 141, 1935.

In this article, Dr. Vianna gives the results of a study of the principal causes of club-foot, including a review of the methods of treatment up to the present time, as well as those which are used by him in the Hospital San Francisco de Asís, in Rio de Janeiro.

His treatment in general depends somewhat on the age of the individual, and is outlined as follows: (1) from birth to the age of three years, manual correction; (2) from three to eight years, surgical treatment of the soft parts; and (3) after eight years, surgical treatment according to the deformity of the tarsus.

After discussing the various surgical methods, including those of Phelps, Kirmisson, Ombrédanne, Farabeuf, Nové-Josserand, Albee, etc., Dr. Vianna describes his method of treating bilateral congenital inverted club-foot by a single operation. If one of the inverted club feet shows greater deformity than the other, he performs the wedge-shaped dorsal tarsectomy of Farabeuf, modified to apply to the individual case. On the other foot he performs a tarsectomy according to the method of Phelps and Kirmisson. He then introduces a bone wedge extracted from the tarsus of the other foot. In this way, the two operations can be done at the same time.

The author reports good results in eight of his own cases, one of which has been followed up for three years. In one of the cases, the graft was eliminated without any undue disturbance.

The other surgical methods are not eliminated from his hospital; this procedure is added to the list of operations which are employed.

EVOLUTIÓN CLÍNICA DE LOS INJERTOS ÓSEOS (Clinical Evolution of Bone Grafts). Alberto Inclán. *Cir. Ortop. y Traumatol.*, III, 161, 1935.

After studying the clinical development of the bone graft in some hundreds of cases, Dr. Inclán gives his opinion with reference to the total or partial vitality of the bone graft, stating that the fate of such a graft depends on the biological purposes for which it is used and where it is implanted. When these purposes have been accomplished, the graft as such disappears and is replaced by newly formed bone which varies in structure according to the physiological demands of statics and dynamics, governed by the laws of Wolff. He states that the bone graft must first become united to the bone and must keep its integrity until the changes which result from its presence have been completely accomplished.

The author then presents a clinical and roentgenographic study of the development of bone grafts in cases of delayed union and pseudarthrosis of fractures, fixation of tuberculous joints, fusion of the spine, stabilization of joints, etc. From this study, the following conclusions are drawn:

1. When a bone graft is employed for fixation of a fracture in a case of delayed union, the graft will disappear after union is complete.

2. When a bone graft is used for fixation of a fracture and in order to fill the gap between the fragments, the graft changes in structure until it attains the size and shape necessary to compensate for the deficiency.

3. If a bone graft is used for extra-articular arthrodesis of the joints, the integrity of the graft is indispensable and should be maintained until the lesion is healed. Progression of the lesion without protection of the bone graft may produce loss of integrity of the graft.

4. When a bone graft is used for stabilizing dislocated or relaxed joints, the structure will change according to the rôle which it is to play. If its purpose is not accomplished, the graft will disappear either partly or entirely.

5. When a bone graft is employed with the object of replacing a large portion of bone, its fixation and osteotrophic action depends upon complete preservation of the graft until the newly formed bone takes on the normal structure; then the bone graft will disappear entirely.

OCHRONOSE UND UNFALL (Ochronosis and Accident). Otto Diebold. *Deutsche Ztschr. f. Chir.*, CCXLV, 63, 1935.

Ochronosis often leads to very marked joint changes, the so called chondrosis dissecans ochronotica. The intervertebral discs, like the cartilages of the joints and ribs, contain dark pigment. They degenerate and become calcified, and an ankylosing process takes place, which does not lead to the formation of spurs and bony bridges. These changes are different from those of hypertrophic arthritis. The involvement of the skeleton represents the most severe type of ochronosis. —*Ernst Freund, M.D., Iowa City, Iowa.*

STÖRUNGEN IM HEILVERKAUF ASEPTISCHER KNIEGELENKOPERATIONEN MIT UND OHNE INFEKTIÖSE GRUNDLAGE (Complications in the Postoperative Course of Aseptic Arthrotomies of the Knee with and without an Infectious Basis). Karl-H[illegible] Magoley. *Deutsche Ztschr. f. Chir.*, CCXLV, 115, 1935.

One hundred and twelve aseptic arthrotomies of the knee joint, performed during a period of five years, are reviewed, with special reference to the postoperative course.

In two cases, thrombophlebitis of the saphenous veins occurred. Both patients were young and the thrombosis subsided with rest in bed. In two cases [illegible] developed and in two, sore throats. In seven cases, there was [illegible] of the knee joint. It seems that knees with lesions of the semilunar cartilages are especially

failure to prevent muscle atrophy and contracture. These conditions are due to postoperative fixation in which the same state of tension is maintained over long periods. Minimal tone is the objective. Postoperative irritation of the joint results in further trauma and inflammatory response. There is excessive postoperative strain. These changes follow in sequence as a rule. The atrophic muscle is easily overstrained.

The therapy is mobilization through active use of the shortened muscle, strengthening of the muscles, and protection of the extremity from overexertion. The mobilization is obtained by the *isometric contraction of the muscle groups,—that is, diminution of tension is produced by the active work of the antagonists, even if no visible motor effect results.* Graded exercises are used to strengthen the muscles. The usual physical therapy agents are also used. The exercises are divided into two groups, those with and *those without a load.*

The author describes two types of limps following operations on the knee,—that due to habit, and that due to real joint disability. The differential diagnosis of these is discussed.

During fixation, exercise should prevent atrophy of *all* the leg muscles except the vastus medialis. Various exercises are described in the article.

The treatment following operation on the menisci is discussed in detail. Heat and massage are not given, as they increase the swelling and effusion. Those patients treated with exercise alone were back at work in one month. In those cases in which heat and massage were used, the patients did not return to work for three months or longer.

Because of their recurrent nature, cruciate-ligament injuries are treated conservatively.—*Albert R. Smith, M.D., Iowa City, Iowa.*

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The Journal of Bone and Joint Surgery

PRESIDENTIAL ADDRESS *

BY FRANK D. DICKSON, M.D., KANSAS CITY, MISSOURI

Somewhat conflicting emotions fill my mind as I stand before you to speak as your retiring President. Needless to say, the deepest feeling is one of gratitude to you for the honor you have done me in selecting me for your fourth President, but there is as well a feeling of doubt as to just how successful my stewardship has been and some perplexity as to the form which my address to you should take. The American Academy of Orthopaedic Surgeons is a mere stripling compared to most national organizations with similar aims and purposes; it is in its swaddling clothes with its life all before it; it has but a suggestion of recorded history, and what is to be written in its record depends upon the course followed in the years to come. It would seem, then, that my address must be one of suggestion for the future rather than a review of past accomplishments. I realize that to give advice is often a thankless task and that he who undertakes it is treading on dangerous ground. Therefore, I am not going to give advice, but I shall simply place before you some of the ideas which have occurred to me during the past year on matters which would seem to be important in charting out the course of the Academy on its voyage into the future.

The American Academy of Orthopaedic Surgeons was organized with a specific purpose in mind; according to the second article of our constitution, this was: "To advance orthopaedic surgery in all its phases". This statement is decidedly general in its implications and might wisely be amplified into something more specific. I believe, then, that without attempting to catalogue the purposes of the Academy it might be worth while at this time to enumerate some of the aspirations held by those most interested in its organization. Among these aspirations were: the formation of an organization with nation-wide representation and, therefore, with nation-wide influence in establishing orthopaedic surgery on the

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 13, 1936.

plane of importance and dignity which it deserves; the elevation of the standards of education in orthopaedic surgery, both undergraduate and graduate; the encouragement of a systematic study of important orthopaedic problems; the promotion of a close relationship with general surgery, looking toward a freer exchange of information and ideas; and, finally, the establishment of an agency to serve as a competent source of advice and guidance on questions of importance to the public.

If this is a fair statement of the aims of the Academy, it is evident that it has chosen a wide field of activity and that it must be prepared to assume considerable responsibility if these aims are to be attained. Responsibility of this order can only be met by an organization whose membership is of excellent caliber, whose policy is simple and direct, whose deliberations are sound, and whose activities are productive of results which mean genuine advancement in our special branch of medicine. May I then speak with you for a while about some of the things which seem important to me as having some bearing on the carrying out of this rather ambitious program?

Addison has said: "Knowledge is, indeed, that which next to virtue truly and essentially raises one man above another." Knowledge may be briefly defined as the aggregate of facts, truths, and principles acquired or retained by the mind. I stress this word "knowledge" because I believe that it, with ethical standing, should be the hallmark which entitles to fellowship in this Academy. Baer wisely said: "Anatomy, physiology, pathology, physics, chemistry, and biology are the fundamental ingredients which, properly mixed, form the science of medicine." The science of medicine has two great divisions,—medicine and surgery; although closely related, still they are separate designs which together make up the intricate pattern of medicine as a whole. Specialties are but sections of these designs and, taken by themselves, mean nothing; they must fit into the pattern in their proper place. Orthopaedic surgery is probably the broadest and most comprehensive of the special branches of medicine, since it wanders through the entire pattern, appearing now in the design of surgery and now in the design of medicine. The orthopaedic surgeon, then, must have not only information on but knowledge of both medicine and surgery. Steindler has aptly suggested that the proper title should be "orthopaedic physician". The orthopaedic surgeon must have the training and ability to carry out complicated and extensive surgical procedures; he must possess surgical judgment in diagnosis and treatment; and he must be equipped to meet surgical emergencies. He is required to understand pathological changes and physiological and chemical reactions. He should be conversant with medical therapeutics and be prepared to use his knowledge in the management of his cases. Finally, he must have a thorough understanding of function and the means available for restoring function once the pathology has been removed or overcome. This is indeed a wide field and one which demands the broadest of medical training and deep, if not profound, knowledge. I believe that

one of the fundamental requirements for fellowship in this body should be that the candidate measure up to that standard of knowledge which it is necessary that an orthopaedic surgeon possess; otherwise, the prestige of the Academy and, through it, that of orthopaedic surgery everywhere will suffer and one of the important purposes of this Academy will be defeated.

Although it may seem like projecting ourselves into the distant future, a crossing of the bridge before we come to it, I should like at this point to allude briefly to certain influences which are making themselves felt in orthopaedic practice and which seem likely to exercise an even more profound influence upon it in the future, and so upon the future position of this Academy from the point of view of its membership. Until the last decade, the orthopaedic surgeon was largely preoccupied with the care of physical defects of congenital origin or the result of accident or disease in children. During the last ten or fifteen years, an increasingly larger part of his time has been taken up with the treatment of traumatic and occupational injuries. This can only mean that orthopaedic surgery today is gradually, perhaps rapidly, expanding its borders to include traumatic surgery. This change is not surprising since orthopaedic training engenders an attitude of mind and cultivates a familiarity with the use of apparatus which well fit the orthopaedic surgeon to care for the serious and destructive injuries encountered in traumatic surgery. Attractive and lucrative as such practice may be, it cannot be pursued too completely or there is danger that we will lose our sense of proportion and cease to be orthopaedic surgeons and become traumatic surgeons. I would suggest to you, particularly to the younger men, that we must be first, last, and always orthopaedic surgeons; that the effective relief of the physically handicapped is the real justification for our existence as a specialty; that we do not lose sight of the fact that it has been our training as orthopaedic surgeons which has been responsible for any proficiency which we may have in treating traumatic cases, not the reverse; and, finally, that a good traumatic surgeon does not necessarily signify a capable orthopaedic surgeon. Sooner or later, our membership will have to make a decision as to what extent orthopaedic surgery and traumatic surgery can be mixed. We may perhaps be called upon to set up a dividing line and we should be giving some attention to this question in order that mature thought may insure a wise decision.

Probably the most important single influence in determining the course which a medical student will follow after graduation is the quality of his undergraduate instruction. It would seem, then, that the Academy should be deeply interested in the kind of orthopaedic training which the students of medicine are receiving to-day and which they are to receive in the future. This applies not only to those who are aiming toward eventually taking up orthopaedic surgery as their life work, but also to all who intend to practise medicine. No course in the medical curriculum can be of greater service to the practising physician than one which gives

him a working knowledge of the orthopaedic problems, since they are of relatively frequent occurrence in general practice. The Academy has set up as one of its requirements for fellowship that the candidate shall have had adequate training in orthopaedic surgery. What constitutes an adequate training? Hitherto it has meant that the applicant has been associated with a recognized orthopaedic surgeon or has taken postgraduate work for a period of time and has gained approval by the quality of his work. Is this not perhaps a rather loose standard, since it by no means gives assurance that the training has been well-rounded and complete enough to fit the individual to meet adequately all the demands which may be made upon him? Should not the Academy outline a course of postgraduate study along flexible lines which would be comprehensive enough to be acceptable as adequate training, and require that those who offer postgraduate courses or training follow this plan? The American Orthopaedic Association has a Committee on Undergraduate Instruction in Orthopaedic Surgery which has made a careful study of orthopaedic instruction and a year or two ago submitted a report. What has been accomplished toward putting into effect the recommendations of this Committee I am unable to say, but I question whether the acceptance of its proposals has been wide-spread. Certainly, if it is to carry out the spirit of its stated purpose, this Academy should join actively with other interested bodies not only in planning but also in putting into effect adequate orthopaedic teaching; yet in our list of standing committees there is no Committee on Medical Education. This omission should be remedied and a strong and active committee be formed to deal with this important subject.

Closely related to orthopaedic instruction in establishing a reasonable proficiency in orthopaedic practice is the need for some sort of standard for determining the fitness of the aspirant desiring to practise orthopaedic surgery as a specialty. There has been established under proper authority the American Board of Orthopaedic Surgery, which has been granted the right to issue certificates of proficiency or approval. Is it not most desirable that all Fellows of the Academy should hold certificates from this Board and that in the near future the requirements for fellowship should include such certification? Certainly, the Board should have the endorsement and support of the Academy, and such approval can be expressed only in this way.

I believe that the purpose most generally stressed in the discussions which led to the formation of the Academy was the part it might play in fostering the investigation of medical problems in the solution of which orthopaedic surgeons might be expected to provide leadership. It was felt that an active and wide-spread membership would provide opportunities for collecting data on the results of treatment from many sources and that this material, when assembled and studied by committees of the Academy, would allow important and helpful conclusions to be drawn which would be far more authoritative than the observations of individual

workers. That the Academy has made an excellent start in this direction is evidenced by the fact that this year symposia arranged by two committees are appearing as part of our program. There are, however, many avenues of investigation along which the Academy must press if it is to hold up its end in medical progress. For me to attempt to indicate the paths which such investigations should follow would be presumptuous. I would merely suggest a few which have occurred to me, such as an evaluation of the newer operations for stimulating or retarding bone growth, additional inquiry into the operations on the sympathetic system for the relief of spasticity and to increase growth in paralyzed limbs, and a study of the endocrine system not only in relation to important bone conditions but as to the effects of endocrine imbalance on developmental and postural problems in growing children. If these suggested lines of inquiry and a host of others which will readily occur to you fall within the scope of the Committee for Scientific Research, I hope that this Committee is actively engaged upon plans for forwarding them; if not, then I suggest that this Committee be enlarged so that it may do so, since help in arriving at sound conclusions on newly suggested and incompletely tested facts should be one of the vital activities of this Academy.

The relation which orthopaedic surgery bears to general surgery is a very close one. Orthopaedic surgery is a subdivision of general surgery and, no matter how strong and robust we may believe ourselves to be, we cannot divorce ourselves from general surgery, nor should we desire to do so. There should be the closest unity between the general surgeon and the orthopaedic surgeon and the freest interchange of ideas, since both are working for the same purpose,—restoring the ill and the disabled to health and usefulness. One of the wisest of those who have served the interests of orthopaedic surgery, the late Nathaniel Allison, constantly cautioned against orthopaedic surgery's isolating itself, since such isolation inevitably leads to narrowness and loss of vitality and progressiveness. Let us keep our contacts with general surgery and even draw them closer; it will help both the general surgeon and ourselves. The Academy has indicated an appreciation of the advantage of such an alliance by providing for Associate Members who need not be Simon-pure orthopaedic surgeons. If judiciously chosen, the Associate Membership should be a very vital part of our Academy.

In these days of change, social upheaval, and very articulate demands for social security, there seems to be a growing desire for some form of altered relationship between the medical profession and its patients, the public. There has been a regrettable lack of interest displayed by the individual members of the profession in this very important and live subject, so that apparently the responsibility of shaping the many unsound and unworkable theories put forward for its solution into some workable and responsible plan must devolve upon organized medical bodies. The American Medical Association and the state and county medical societies are becoming more and more alive to the necessity of medical leadership

in shaping these plans. The orthopaedic case has aspects which demand plans differing in detail at least from those which fit the general run of medical and surgical cases and it would seem important that our Committee on Legislation and Medical Economics be prepared to make its voice heard in formulating these plans when the opportunity presents itself. Even more important, however, is the individual responsibility of the large and wide-spread membership of the Academy to interest itself locally in both general medical economic planning and the particular planning which has to do with the care of the physically handicapped. In this way, and in this way only, can the Academy fulfill its obligation to the public and provide that leadership which the public has a right to expect of us.

Since I have wandered so far afield and, contrary to my stated intentions, have ventured to give what sounds suspiciously like advice, I will go all the way and mention before closing one other impression which has been growing upon me in recent years, since it concerns a matter on which the Academy should take a definite position. I mean the tendency toward what might be termed the mechanization of orthopaedic practice. One cannot but be impressed by the bewildering array of splints, wires, pins, traction apparatus, and gadgets of all sorts which have been recommended or have come into use in the past few years for the correction of deformity and reduction and splinting of fractures. At the risk of being considered old-fashioned or reactionary, I must express the hope that this Academy will see fit to take a position in its deliberations which will suggest a "breathing spell" in the introduction of mechanical devices, so that we may allow ourselves time to evaluate properly the place in orthopaedic practice of those already in use. This evergrowing increase in the use of mechanical contrivances and the dependence upon them seems to carry with it some very real dangers,—namely, the tendency to rely upon a mechanism to do the work for us instead of doing it ourselves; the fostering of a lack of exactness in clinical examination and of meticulous supervision, so important in the management of a case; the encouragement of a belief that mechanical devices can alter or hasten healing instead of merely, at the best, supplying a more efficient mechanical support; and, finally, the likelihood that the inexperienced and insufficiently trained individual, by relying upon a mechanism to make up what he himself lacks, may be encouraged to undertake the treatment of conditions he is unfitted to care for. I would not be understood as undervaluing mechanical aids, many of which have been of the greatest service and are indispensable to efficient treatment, or of desiring to obstruct progress. I would merely warn against the too ready acceptance of every new device suggested until a careful study has shown that it is mechanically right and that its use is based on sound physiological principles. It would not be inconsistent for the Academy to take the position that it is incumbent upon those who seek to replace an accepted method of treatment by a mechanical device that they show that the method they propose will greatly diminish or

altogether prevent the failures of the method they seek to supplant. Stated in another way, we should require that their work be tested by results as well as theory and intentions before acceptance.

This address has been prolonged far beyond the limits originally set and must be brought to an end. If I have been overinclined to impose upon you my personal views, it has been because there seemed no other way to bring to your attention matters touching the future policy of the Academy which appear to be important, judged in the light of my experience as your President during the past year.

In closing, I should like to express to you my conception of the position in which the Academy finds itself after three years of activity and very rapid growth. The American Academy of Orthopaedic Surgeons has been safely launched; it has started on what promises to be a most successful voyage; its future is in your hands to do with it what you will. While its destiny is beyond our powers to envision, there is no doubt in my mind that in the years to come it will build up a record of service and usefulness commensurate with the high aspirations of those who conceived it, always provided that it charts a true course, setting up as its beacons those honorable and unselfish precepts laid down almost fifty years ago by that splendid group of men who founded the specialty of orthopaedic surgery.

OPERATIVE RECONSTRUCTION OF MALUNITED FRACTURES ABOUT THE ANKLE JOINT *

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Malunion following the usual bimalleolar fracture (Pott's type), or the trimalleolar fracture of the ankle (Cotton's type), occurs not infrequently, even in the hands of those experienced in the treatment of these fractures. The ankle is a weight-bearing joint, hence even minor disturbances in the relation of the articular surfaces or distortion of the weight-bearing alignment of the joint may produce serious and persistent dysfunction. After these fractures have become partially or completely united, further closed manipulation is usually inadequate and may be disastrous. In consequence, some type of open operative reconstruction is required for the relief of the disability.

There is little available material in the literature to guide one in the choice of operative procedure to be employed for the correction of the various deformities. While each case is an individual problem and no set rules can be applied to any group, it was felt that a study of a series of these reconstruction operations might lead to more definite conclusions as to which procedures were most practical, and might indicate the type of reconstruction which has given the best functional results in each group as a whole.

The following report is based on a study of some fifty operations of various types for malunited fractures about the ankle. The procedures employed are described and an attempt is made to estimate their value by the functional results obtained. A thorough knowledge of the anatomy of the ankle joint, including the relation of the articular surfaces to the ligamentous supports, is essential to the proper conception of the problems involved in deciding on the type of reconstruction operation to be employed. The ligaments and bony structures which compose the ankle joint have been previously described in many articles; therefore, such a description will not be included in this study. It should be remembered, however, that, due to the ligamentous attachment between the lower end of the fibula and the astragalus, these two bones generally move as one in displacements following fractures about the ankle. The posterior tibiofibular ligament joins the lower end of the fibula to the posterior surface of the tibia; consequently, in fractures of the posterior margin of the tibia, the detached tibial fragment usually follows the fibula.

There are three definite requirements which a reconstruction operation must fulfill in order to preserve motion in the ankle:

1. Restoration of the proper weight-bearing alignment of the leg as a whole;

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2. Restoration of the normal anatomical relationship between the articular surfaces of the tibia and the astragalus;
3. Restoration of a satisfactory range of painless motion.

Experience has shown that, if these requirements are not fulfilled, unsatisfactory functional results are obtained in a high percentage of cases. It is desirable in all cases, where possible, to preserve motion in the ankle joint and every effort should be made to attain this end. A study of the end results in this series of reconstruction operations has shown that in certain types of malunited fractures, particularly the trimalleolar (Cotton's fracture), efforts to preserve motion in the ankle joint have resulted in poor function in approximately 75 per cent. of the cases. Consequently, a more radical type of reconstruction, such as a fusion of the ankle, should be considered as a primary procedure in the more severe types of fractures or in cases of long standing.

The combined operative and manipulative traumata should not be so excessive as to fracture the articular surfaces or to damage them so that traumatic arthritis is the inevitable end result. A stiff, painless ankle is much more serviceable than one with limited, painful motion.

For convenience of description, these fractures have been divided into two groups: first, fractures of the internal and external malleoli, or the Pott's type of fracture; second, fractures of the internal and external malleoli combined with fractures of the posterior margin of the tibia, the trimalleolar or Cotton's type of fracture.

Pott's Type of Fracture

A study of the results in this group has shown that the conservative types of reconstruction operations which preserve motion in the ankle joint have proved satisfactory in the majority of cases and should be used as the primary procedure in most cases. Where this type of operation fails to correct the deformity, or where subsequent traumatic arthritis with persistent disability occurs, a fusion of the ankle should be employed as a secondary procedure.

The simplest type of fracture at the ankle is the eversion fracture, involving the lower end of the fibula without fracture of the internal malleolus. Where lateral displacement occurs, the deltoid ligament is, of necessity, partially or completely ruptured, which allows the astragalus to be displaced laterally with the fibular fragment. Following reduction of the fracture, valgus deformity is not uncommon because the internal anchorage normally afforded by the deltoid ligament has been lost.

In this type of fracture, where there is malunion with valgus deformity, the reconstruction is relatively simple. An osteotomy of the fibula, followed by manipulation, will usually effect a correction. Occasionally, the space between the internal malleolus and the astragalus is filled with scar tissue which must be excised before the astragalus can be approximated to the internal malleolus. If the ankle is held in the corrected position by postoperative immobilization sufficiently long for

FIG. 1-A
The typical malunion of a bimalleolar Pott's fracture.

FIG. 1-B
Result after usual reconstruction operation, showing correction of the deformity by bimalleolar osteotomy and lengthening of the tendo achillis. Correction in these cases is facilitated by thorough mobilization of the external malleolus.

complete and solid union to occur in the fibula, it is usually unnecessary to repair the deltoid ligament.

The second in this group is the bimalleolar fracture in which union has taken place with lateral and posterior displacement of the astragalus (Fig. 1-A). The operative correction here depends on thorough mobiliza-

tion of the external malleolus to permit correction of the fibular shortening and the external rotation of the lower fibular fragment. The pro-

FIG. 2-A

Eversion type of Pott's fracture in which the tibial fragment includes the whole lower end of the tibia, united in valgus deformity. The relation of the joint surfaces is not disturbed. This is an ideal type of case for supramalleolar osteotomy.

FIG. 2-B

Excellent anatomical and functional result following reconstruction by s[illegible] malleolar osteotomy.

cedure allows the astragalus to move forward and to rotate medially, thus restoring the normal relationship between the articular surfaces of the astragalus and the tibia. The increased length of the fibula corrects the valgus deformity. An osteotomy of the internal malleolus should be done in those cases where it is solidly united in malposition. This osteotomy is done preferably through the medial portion of the tibia, just above the old line of fracture in the internal malleolus, as this site gives a broader osseous surface for union. In cases where the fracture of the fibula has occurred two or more inches above the ankle joint, it is preferable to do an osteotomy through the old fracture line, which restores the normal fibular length at the site of the old fracture. This is possible in the recent cases before scar tissue has organized. In cases of longer duration, such a procedure does not permit sufficient mobilization of the lower end of the fibula. In these cases, an oblique osteotomy of the fibula at the joint line allows lengthening of the fibula and also sufficient mobilization to effect correction of the deformity. In addition to the bimalleolar osteotomy, lengthening of the *tendo achillis* is necessary when there is an equinus deformity.

In fractures which have united with a valgus deformity, but in which the normal relationship between the articular surfaces of the tibia and astragalus has not been materially changed, a supramalleolar osteotomy may be the operation of choice. Here an osteotomy of the tibia is done well above the joint line at the position which appears best suited to correct the angulation. A corresponding osteotomy of the fibula is performed at the desired level. The valgus deformity can then be corrected and the normal weight-bearing alignment of the foot and ankle can be restored without an extensive operation on the soft structures about the ankle joint proper. The execution of this procedure is much easier and possible damage to the articular surfaces of the ankle joint is obviated.

The supramalleolar osteotomy is the ideal operation to use in the rare cases which Ashhurst has classified as type-three eversion fractures, where, instead of the usual fracture of the internal malleolus, the fracture line extends across the entire lower end of the tibia just above the joint surface (Fig. 2-A). In these cases, there is little disturbance in the relationship between the articular surfaces of the ankle joint. The valgus deformity is due to angulation at the fracture site and is easily corrected by a suitable osteotomy at this point. The results in all cases of this type have been excellent. (See Figure 2-B.).

The supramalleolar osteotomy should be reserved for those cases in which the valgus deformity is associated with a relatively normal relationship between the articular surfaces of the tibia and astragalus. In order to avoid extensive surgery about the ankle joint proper, in one case of Pott's fracture in this series, an effort was made to restore function by simply correcting the valgus deformity and restoring the weight-bearing alignment by a supramalleolar osteotomy. The altered relationship

FIG. 3-A

Pott's fracture with valgus deformity and disturbed relationship between the articular surfaces of the tibia and the astragalus.

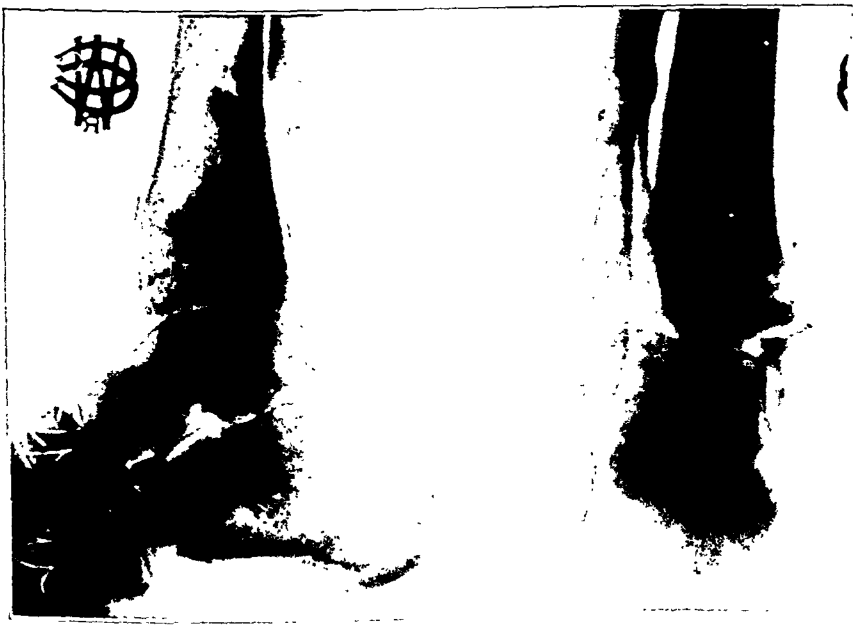

FIG. 3-B

Result of reconstruction operation in which the weight-bearing alignment of the leg was restored by correction of the valgus deformity and the altered relationship between the articular surfaces of the ankle joint was disregarded. The functional result was unsatisfactory, illustrating the fact that restoration of the normal relationship between the articular surfaces is just as important as correction of the weight-bearing alignment.

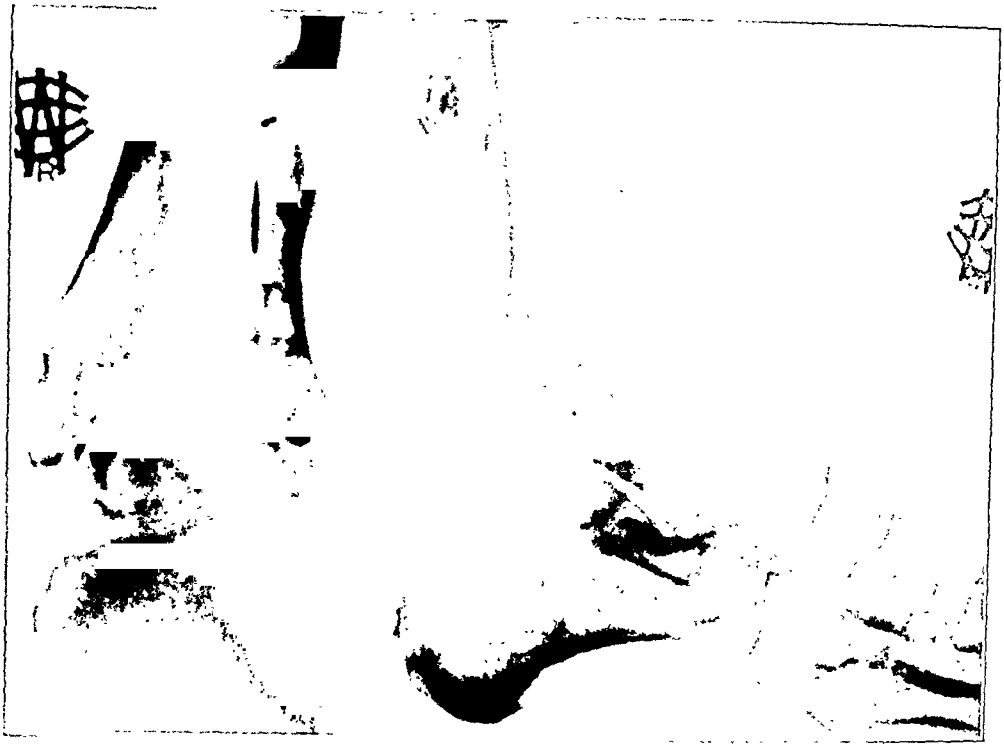

FIG. 4-A

Malunion of Pott's fracture of long standing with distortion of the joint surfaces and traumatic arthritis, resulting in persistent disability. Fusion of the ankle is indicated as a primary procedure in this type of case.

FIG. 4-B

Postoperative result of fusion by the posterior approach.

between the articular surfaces of the astragalus and the tibia was disregarded. A very satisfactory correction of the weight-bearing alignment of the leg as a whole was secured, but the joint remained painful and func-

tion was not improved because of the persisting disturbance in the relation of the joint surfaces. This case illustrates the fact that restoration

FIG. 5-A

Malunion of the simplest type of Cotton's fracture. The posterior fragment is very small; therefore, enough of the articular surface of the tibia remains to insure stability of reduction.

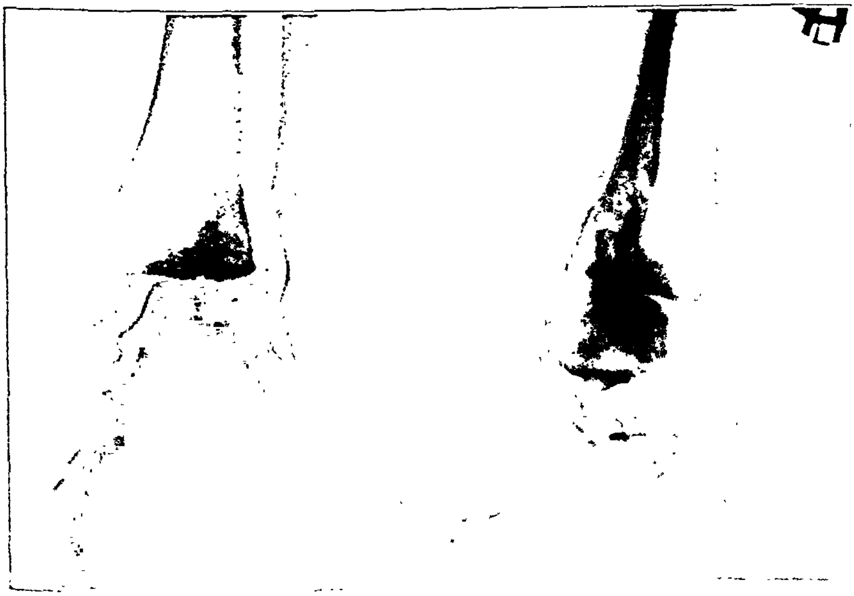

FIG. 5-B

Result of reconstruction operation in which osteotomy [illegible] of the tendo achillis, and manipulation [illegible] to restore the normal relation of the joint.

FIG. 6-A

Typical trimalleolar fracture, with large posterior fragment, in which posterior dislocation of the astragalus recurred during immobilization in a cast. In such a case, open reduction, with some means of internal fixation, is necessary to prevent further recurrence of the deformity and a type of malunion which is difficult or impossible to reduce later.

FIG. 6-B

Ten weeks after injury, showing result of open reduction and internal fixation. Normal function has been restored.

of the proper relation of the articular surfaces is just as essential as correction of the weight-bearing alignment (Figs. 3-A and 3-B).

Cotton's Type of Fracture

In this group of trimalleolar fractures, reduction is more difficult and it is harder to maintain the fragments in position at the time of the fracture; consequently, malunion occurs relatively more frequently. This is due to the fact that the support of the posterior malleolus, often including as much as one-half of the articular surface of the tibia, is displaced. This fragment is firmly attached by ligaments to the astrag-

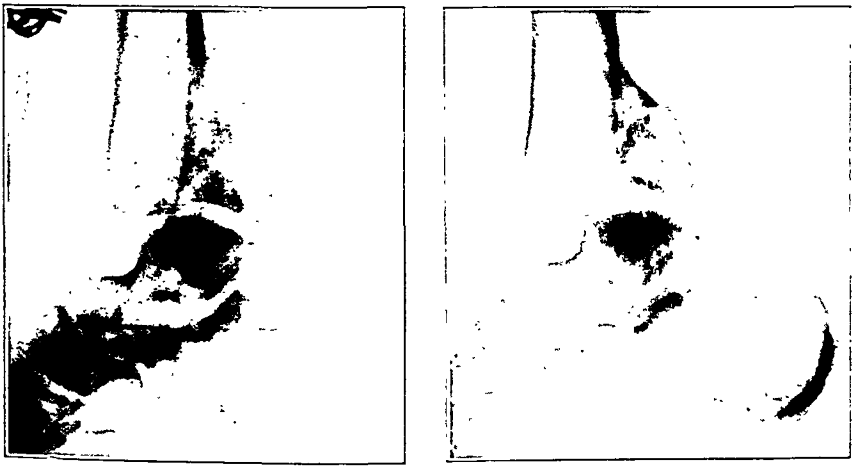

FIG. 7-A

Satisfactory closed reduction of a typical trimalleolar fracture, followed by recurrence of deformity and malunion with severe dysfunction. A reconstruction operation was done at the end of one year. Extensive operative procedure was necessary to correct the deformity.

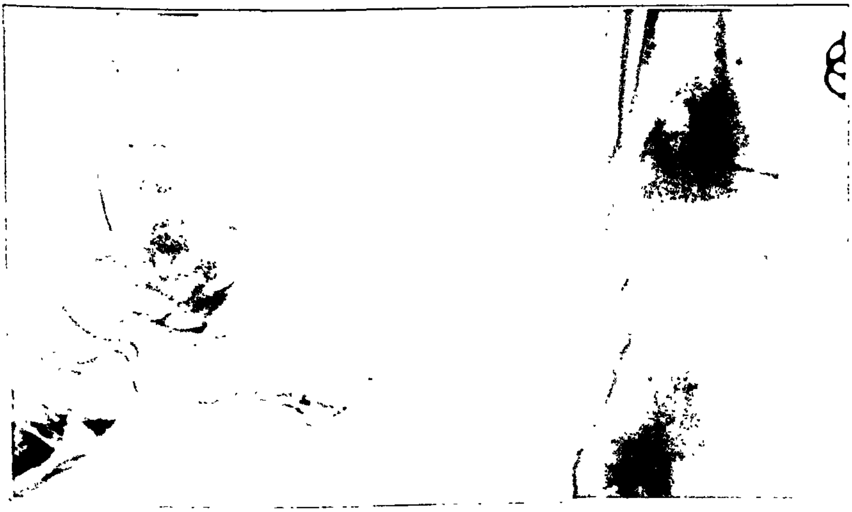

FIG. 7-B

Result five years after reconstruction: deformity corrected and fragments united in good position. The result was unsatisfactory because of extensive degenerative arthritic changes in the joint. Fusion of the ankle was advised for relief of the disability.

alus and external malleolus. Thus, in the deformity the three move together, posteriorly and upward as well as laterally. Where as much as one-third of the articular surface is included in the posterior fragment, the foot must be placed in equinus to secure reduction. Efforts to pull the posterior fragments down by strong dorsiflexion of the foot result only in posterior displacement of the astragalus and further upward displacement of the posterior fragment. With the foot in a cast, in the position of equinus, the recurrence of the posterior displacement of the astragalus is not infrequent. Because of this possibility, frequent postoperative examinations, by means of roentgenograms taken through the cast, are necessary. If the deformity is found to have recurred, a definite plan of action should be instituted in order to prevent malunion, the correction of which is extremely difficult or impossible. If the recurrence of the deformity is discovered in the first three or four weeks after reduction, a satisfactory reposition of the fragments may be obtained by open reduction, using some means of internal fixation to hold the posterior fragment in position. Further attempts at closed manipulation usually are unsuccessful in restoring the posterior fragment to proper position. If, by good fortune, proper reduction is obtained, no further safeguard has been added to prevent another recurrence of the deformity. Open reduction, then, is indicated when the fracture cannot be satisfactorily reduced at the time of the original manipulation or when the deformity has recurred during immobilization. Some type of internal fixation, such as a nail or screw, should be used to hold the posterior fragment in its proper position. The results following this plan of treatment have proved satisfactory. (See Figures 6-A and 6-B.) It is true that in any individual case the fragments may be remanipulated and their position maintained. Taken as a class, however, fewer cases of malunion will occur in this group of fractures if open reduction and some type of internal fixation are used.

When definite malunion has occurred in trimalleolar fractures, reconstruction operations which attempt to preserve motion in the ankle joint are always difficult and frequently impossible. The difficulty depends largely upon two factors: first, the size of the posterior fragment; second, the extent of the organization of the scar tissue and the amount of osteoporosis of the bone. When the posterior fragment is small and there is very little posterior displacement of the astragalus, the same operative principles which govern the treatment of Pott's fractures may be employed. In such a case, the displacement of the posterior fragment can usually be corrected by the usual procedures employed to correct the lateral displacement and external rotation. In cases where the posterior fragment is small, there is enough of the articular surface of the tibia left to insure the stability of the reduction.

In the typical trimalleolar fracture with malunion, where the posterior fragment includes as much as one-third to one-half of the articular surface of the tibia and where the astragalus is displaced posteriorly, the reconstruction operation becomes much more difficult. Correction of the

valgus and external rotation offers no more difficulty than in the usual Pott's fracture. The real difficulty is found in mobilizing the displaced posterior fragment and in bringing the astragalus forward to its normal position under the articular surface of the tibia. The firm organization of scar tissue and the contracture of the posterior capsule and the tendo achillis hold the astragalus firmly in its position of posterior displacement. Even after extensive loosening of the soft tissues and ligaments about the ankle joint, including incisions on the inner and outer sides of the ankle and lengthening of the tendo achillis, strenuous manipulation is necessary to push the astragalus forward. The combined dissection and manipulation procedures are often sufficient to damage the joint surfaces, resulting in traumatic arthritis which impairs future function, even though the deformity may be corrected. The following case illustrates such a result.

The patient was first seen with an acute trimalleolar fracture which had been satisfactorily reduced, but in which the deformity had recurred during immobilization in a cast (Fig. 7-A). Because of other complicating injuries, further treatment of the fracture was impossible and malunion occurred, with slight upward displacement of the posterior fragment and posterior displacement of the astragalus. A reconstruction operation was done one year later, at which time the displacement of the astragalus was corrected and the posterior fragment was brought down into its normal position, where it was held until solid union took place. Pain, swelling, and disability in the ankle persisted. Further roentgenograms (Fig. 7-B), five years after the reconstruction operation, showed a good anatomical correction of all the deformities, but sufficient degenerative changes in the articular surfaces of the ankle joint to impair function seriously. Because of the persistent disability, a fusion of the ankle was advised at this time.

In other cases where the difficulty of correction of the posterior displacement of the astragalus is realized and every effort is made to accomplish it by wide exposure of the joint and thorough excision of the contracted scar tissue, combined with the usual osteotomies of the malleoli, it is impossible to obtain a satisfactory operative correction of the deformity. These incomplete conservative operations have universally proved unsatisfactory. In consequence, when such difficulties are encountered during the operative procedures, it is better to fuse the ankle joint than to attempt to preserve ankle motion.

Excessive manipulative force should be avoided in attempting to overcome the deformity in these resistant cases. Further crushing or fracturing of the joint surfaces may occur. This is especially true where osteoporosis is present. In 75 per cent. of the cases of this type in the present series, conservative reconstruction operations resulted in such poor function that fusion operations would obviously have been the better procedure.

One case in this series was particularly instructive, as it not only showed the difficulties and dangers which accompany the usual conservative reconstruction operation, but it also suggested the means of overcoming these difficulties.

In this case there was a malunited trimalleolar fracture with both lateral and posterior deformity. Moderate osteoporosis was present. A [illegible]

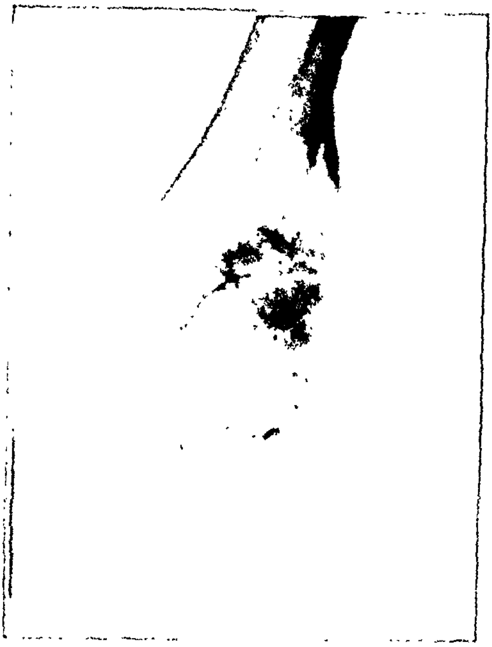

FIG. 8-A

Trimalleolar fracture with malunion of nine months' duration. Moderate osteoporosis was present.

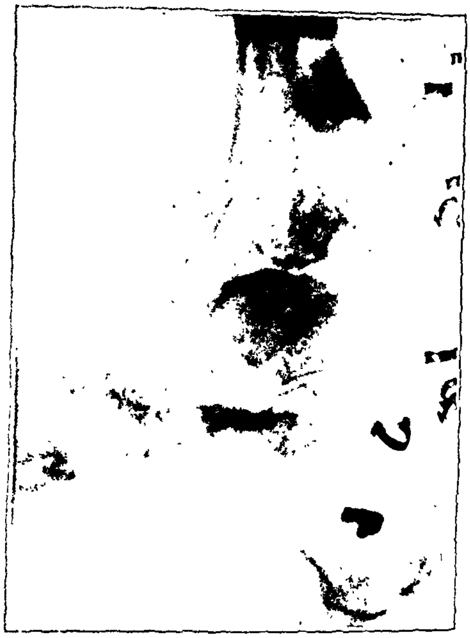

FIG. 8-B

Condition immediately following reconstruction operation. After bimalleolar osteotomy, lengthening of the tendo achillis, and freeing of the soft tissues, considerable manipulative force was still necessary to correct the deformity. This resulted in crushing and comminution of the remaining articular surface of the tibia. The functional result was poor at the end of one year.

operation was attempted. Great difficulty was experienced in trying to mobilize the posterior malleolus and to bring the astragalus forward to its normal position. Only moderate manipulative force was used, but this resulted in crushing and comminution of the remaining articular surface of the tibia. Both the lateral and posterior deformities were finally corrected

FIG. 8-C

Condition five years after reconstruction operation: spontaneous fusion in good position, followed by a good functional result.

FIG. 9-A

Malunion of trimalleolar fracture, with inability of the patient to walk on the foot at the end of eight months.

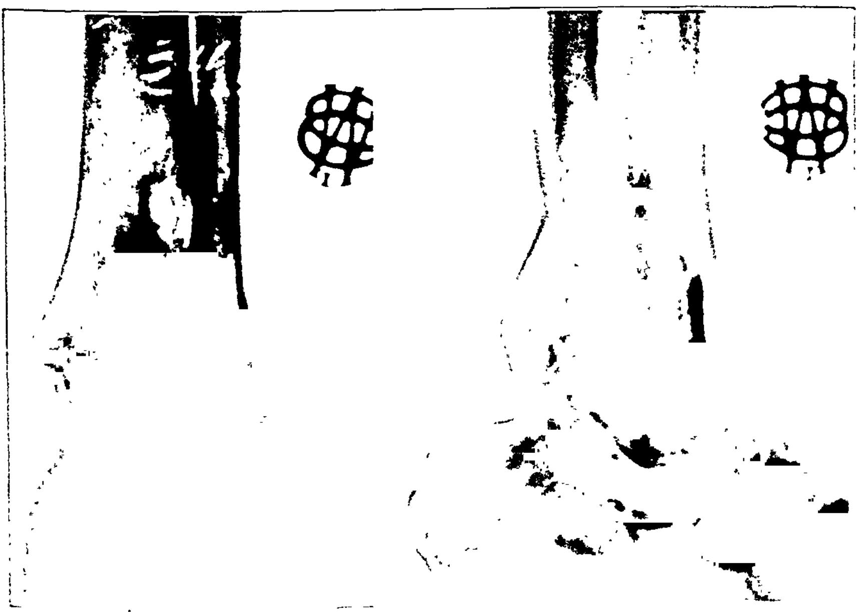

FIG. 9-B

Result following primary fusion of the ankle by anterior approach: satisfactory correction of the deformity and good functional result. This illustrates the type of fracture in which primary fusion of the ankle is indicated.

and the fracture united in good anatomical alignment. Pain and disability persisted and the patient was using crutches at the end of a year, at which time she disappeared from observation. At the end of four years, she returned, stating that her ankle gave her very little pain and that she had excellent function. Roentgenograms revealed a spontaneous fusion of the ankle in good position. An examination of the foot showed the development of excellent compensatory motion in the midtarsal and subastragalar joints.

Here nature had intervened and had provided a solution which should be a guide to the surgeon in the treatment of similar cases. (See Figures 8-A, 8-B, and 8-C.)

FUSION OF THE ANKLE

Experience has shown that for conditions other than malunited fractures, such as tuberculosis, fusion of the ankle has given good functional results. The same results may be obtained by this method in the treatment of malunited fractures in which conservative procedures have failed or in those cases in which experience has shown that a high percentage of poor results follows conservative reconstruction.

A study of the end results in the two groups of cases described has led to definite conclusions regarding the indications for primary fusion of the ankle rather than attempts at conservative reconstruction.

Fusion of the ankle is indicated as a primary procedure in the following types of cases:

1. Pott's fractures, with or without deformity, in which the roentgenograms demonstrate definite arthritic changes, with roughening or distortion of the joint surfaces, resulting in persistent pain and disability.
2. Malunited trimalleolar fractures of long duration, with posterior dislocation of the astragalus and upward displacement of the posterior malleolus.
3. Cases in which, during the course of attempted conservative reconstruction for any of the types of malunion, it is found that the deformity cannot be corrected, or that such extensive operative procedures are necessary or such excessive manipulative force is required that subsequent degenerative changes in the ankle joint appear inevitable.
4. Rare cases of malunion following fracture of the anterior lip of the tibia and forward displacement of the astragalus.

Operative Technique

Fusion of the ankle may be accomplished through either the anterior or posterior approach. A fusion by the posterior route was originally designed as an extra-articular procedure to be employed in such conditions as tuberculosis. In fusion by the posterior approach, the tendo achillis is divided and the back of the ankle joint is exposed. The posterior surface of the tibia is denuded and an arthrodesis of the subastragalar joint is done. Bone chips are then turned up from the os calcis and down from the tibia to bridge completely the denuded area between the os calcis and the tibia.

In fusion by the anterior route, the joint is exposed by an incision over the anterior surface of the ankle, just lateral to the extensor tendons. The anterior surface of the joint is thoroughly exposed, giving a clear view of both internal and external malleoli. The astragalus and the tibia are denuded of articular cartilage and sufficient bone is removed to provide an unobstructed view of the entire ankle joint. When present, lateral deformity is corrected by osteotomy of the fibula and mobilization of the external malleolus. If necessary, the tendo achillis is lengthened to correct the equinus deformity. If difficulty is still encountered in bringing the astragalus forward to its proper position, further dissection of the soft tissues, often including division of the posterior capsule, is done. The articular cartilage is next removed from the internal and external malleoli. The astragalus is then brought into position, correcting both the posterior and lateral deformity. A graft, two and five-tenths by five centimeters, including the entire thickness of the cortex, is next removed from the anterior surface of the tibia. This graft is dropped down across the joint and countersunk into the neck of the astragalus. The lèg is immobilized in a plaster cast, with the foot in the position of slight equinus without inversion or eversion. It is felt that slight equinus is desirable, particularly in women, to allow for the heel of the shoe.

Fusion by the anterior route has certain distinct advantages over that by the posterior approach. The anterior approach permits a wider exposure of the important structures in the operative field and gives a clearer view of the joint after correction has been obtained. It allows a complete denudation of the joint surfaces and facilitates the removal of sufficient bone from the tibia and the astragalus to correct the posterior displacement. It does not sacrifice motion in the subastragalar joint. When the astragalotibial joint is fused, the compensatory motion afforded by the subastragalar joint is extremely useful in permitting sufficient lateral mobility to enable the patient to walk over rough ground. The anterior approach has the disadvantage of requiring a second incision when lengthening of the tendo achillis is necessary.

Clinical Application

Primary fusion of the ankle was considered to be indicated and was performed in eight cases of this series. It was advised as a secondary procedure in five cases in which the results were unsatisfactory following the more conservative type of reconstruction operation. The results following fusion of the ankle for malunion have been most gratifying. The patients have complained of some difficulty in walking over rough ground, especially those whose ankles were fused by the posterior approach; otherwise, the joints have satisfactorily withstood the functional demands of ordinary use.

CONCLUSIONS

1. The majority of malunited Pott's fractures can be satisfactorily

corrected by conservative operations which preserve motion in the ankle joint.

2. *In acute trimalleolar fractures (Cotton's type)*, an open operation should be done when it is impossible to secure satisfactory position at the original manipulation or when the deformity recurs during immobilization. In performing such an operation, it is preferable to use some type of internal fixation for the posterior fragment.

3. In cases of malunion following trimalleolar fractures of the more severe types or of long duration, conservative reconstruction operations result in a high percentage of poor functional results.

4. *Fusion of the ankle is indicated as a primary procedure in certain* types of malunion where experience has shown that conservative reconstructions are unsatisfactory.

5. Fusion of the ankle is indicated as a secondary procedure in those cases of malunion where a more conservative type of reconstruction has failed.

PROGNOSIS AND TREATMENT OF TUBERCULOSIS OF THE BONES OF THE FOOT

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The prognosis and treatment of tuberculosis of the bones of the foot, as well as of tuberculosis of other parts of the skeleton, are governed largely by three factors: the age of the patient, the type and duration of the disease, and the social status of the patient.

In childhood, it is generally conceded that the prognosis is favorable with conservative treatment if such treatment is carried out consistently and proper attention is given to the usual hygienic measures, special emphasis being placed on heliotherapy and immobilization. Occasionally, minor operations—such as the laying open of a sinus or the excavation of an isolated focus in a single bone—are justified, but radical procedures—such as the removal of one or more tarsal bones or the amputation of the extremity—are rarely called for, except in the most advanced cases. Humphries and Durham reported the end results of conservative treatment in twenty-nine patients whose ages averaged five and one-half years at the beginning of treatment. The average duration of treatment was four and one-sixth years. Twenty-three patients were cured: fifteen obtained full function and eight, partial function.

In 1910, Sever published the results of a study of the cases of tuberculosis of the ankle joint and foot seen at the Children's Hospital, Boston, from 1868 to 1910. He concluded that in children conservative treatment is better than operative treatment, since it causes less secondary joint involvement and other spread of the disease and results in more satisfactory healing and a greater degree of function of the joints. Fitzsimmons studied the subsequent cases (1910–1920) at the same institution and arrived at similar conclusions.

Rollier and Lo Grasso treated both children and adults conservatively and obtained an ultimate cure in 90 per cent. of the cases. Three-fourths of these patients acquired normal function and the remainder, partial function.

Most reports of adult patients show comparatively poor results from conservative treatment. Jones, Murphy, Hibbs, Brackett, Gaenslen, Geist, and many others have advocated, particularly in elderly individuals, early fusion of the involved joints, excision of the tuberculous tissue, or arthrectomy. McGavin, Cotton, Chiari, and Calvé also place emphasis on surgical treatment in adults. For the early cases, they recommend extensive tarsectomy and for the advanced cases, amputation. Most authors condemn simple curettage, contending that, since all of the diseased tissue is not removed, healthy areas are exposed for fresh infection.

McGavin makes an exception by advocating curettage for localized lesions of the smaller tarsal bones such as the cuboid and scaphoid.

In the selection of a method of treatment in individual cases, the social status of the patient should be considered carefully. This is especially true in countries such as China where approximately 90 per cent. of the patients are too poor to afford long periods of conservative management and where, through difficulties imposed by the distance of the patients' homes from a hospital and lack of education, the disease is likely to be far advanced before treatment is sought. In a high percentage of our cases, when the patients presented themselves for treatment, the feet showed marked swelling, infiltration of the soft tissues, and draining sinuses. Many of these patients were malnourished and showed active tuberculosis in other parts of the body. Therefore, radical operations, particularly amputation, were frequently required. Often amputation was called for simply because it was necessary that the patient be returned to work at the earliest possible time, whereas more conservative surgical management would otherwise have been clearly indicated.

There are two main types of tuberculous disease of the foot, each having certain characteristics which are determined by the reaction of the tissue in which the infection is located. If the local lesion begins in the synovial tissue or surrounding soft tissue, the infection is liable to spread widely by direct extension through several of the joints. This is the infiltrating type which gradually involves one or more of the bones and presents early the clinical symptoms and signs of inflammation, such as pain, tenderness, local heat, and swelling. When the lesion starts in the central portion of one of the bones, the patient may complain only of a dull aching pain for several weeks or even several months. If untreated, this latter type of lesion extends gradually through the cortex to involve the proximal joints and bones. When the cortex has been perforated, the disease may assume the clinical nature of the infiltrating or synovial type.

The following statistics and comments are concerned chiefly with the results of surgical treatment in a wide variety of tuberculous lesions of the foot. Most of the lesions were relatively well advanced before the patients came to seek relief and, therefore, our results should be evaluated separately from those of clinics in other countries where the social conditions are better and where the disease is no longer as severe in its manifestations or as prevalent as it is in China. In practically all of our cases there were indications for early surgical treatment, particularly amputation. However, by means of radical excision of the diseased soft tissue and bone, we were able to eradicate the local disease and to save a useful portion of the foot in 20 per cent. of these cases. In this report, we wish particularly to emphasize the indications for the latter procedure.

STATISTICS OF TREATMENT

From 1920 to 1934, 147 cases of tuberculosis of the bones of the foot were examined in the Peiping Union Medical College Hospital. Active

TABLE I

DISTRIBUTION OF CASES ACCORDING TO AGE GROUPS

Age Group	Males		Females	
	No. of Cases	*Per Cent.*	*No. of Cases*	*Per Cent.*
1–5	2	2.2	0	0.0
5–10	3	3.3	9	15.8
10–20	26	28.9	26	45.6
20–30	50	55.6	12	21.1
30–40	5	5.6	8	14.0
40–50	2	2.2	2	3.5
50–60	2	2.2	0	0.0
Total	90	100.0	57	100.0

treatment was instituted in 129 of these cases. Of the eighteen untreated cases, there were: eight in which treatment was not instituted because of a very advanced or terminal stage of associated pulmonary tuberculosis; seven in which treatment was refused by the patient; one in which death

TABLE II

OCCURRENCE OF TUBERCULOSIS IN BONES OF THE FOOT

Bone Involved	Single Lesions		Multiple Lesions		Single and Multiple Lesions Combined	
	Frequency of Involvement	*Per Cent.*	*Frequency of Involvement*	*Per Cent.*	*Frequency of Involvement*	*Per Cent.*
Calcaneum	23	41.9	36	9.9	59	14.1
Astragalus	8	14.6	42	11.6	50	12.0
Metatarsal 1	12	21.9	33	9.1	45	10.8
Cuneiform 2	2	3.6	34	9.4	36	8.6
Scaphoid	0	0.0	34	9.4	34	8.1
Cuneiform 1	1	1.8	32	8.8	33	7.9
Cuboid	2	3.6	28	7.6	30	7.2
Cuneiform 3	0	0.0	30	8.3	30	7.2
Metatarsal 2	1	1.8	21	5.8	22	5.3
Metatarsal 4	1	1.8	20	5.5	21	5.0
Metatarsal 5	0	0.0	21	5.8	21	5.0
Metatarsal 3	0	0.0	18	4.9	18	4.3
Phalanx 1	2	3.6	12	3.3	14	3.4
Phalanx 2	2	3.6	2	0.6	4	0.9
Phalanx 5	1	1.8	0	0.0	1	0.2
Phalanx 3 and 4	0	0.0	0	0.0	0	0.0
Total	55 (53 cases)	100.0	363 (94 cases)	100.0	418 (147 cases)	100.0

TABLE III

DURATION OF DISEASE BEFORE FORMATION OF DRAINING SINUSES

Duration in Months	No. of Patients
0-1	31
1-4	46
4-7	25
7-10	6
10-13	11
13-16	0
19-22	2
22-25	0
25-28	1
28-31	1
31-34	0
34-37	0
37-40	2
40-72	2
Total	127

occurred before admission of the patient for treatment; and two in which tuberculous lesions of the toes healed spontaneously.

The diagnosis was confirmed by microscopic examination in 124 cases (84.3 per cent.). In the remaining twenty-three cases (15.6 per cent.), pathological specimens were not obtained, but the clinical diagnosis was made possible on the basis of: (1) a typical clinical course; (2) characteristic findings in the roentgenograms; and (3) evidence of tuberculous lesions in other parts of the body.

As shown in Table I, the disease was slightly more prevalent among the males than among the females, the ratio being 1.6 to 1.0. Also, the disease was more prevalent between the ages of ten and forty years. More than half of the cases among the males occurred within the third decade; among the females, approximately one-half of the cases occurred in the second decade of life.

In Table II, the cases are divided into two groups. The first group of fifty-three patients (36.0 per cent.) had isolated lesions of a single bone; and the second group of ninety-four patients (64.0 per cent.) had multiple lesions of two or more bones. In the first group, two patients showed lesions in both the right and left calcaneum, making a total of fifty-five instances of involvement of a single bone.

In a study of the relative frequency of involvement of the bones of the foot, it may be noted that the disease occurred more frequently in the calcaneum, astragalus, first metatarsal, scaphoid, and the first and second cuneiform bones. These bones are of first importance in transmitting weight from the tibia to the arches of the foot and, therefore, we believe

that the relative preponderance of lesions in these bones is a strong point in favor of the contention that trauma predisposes to the development of tuberculosis.

Out of a total of 147 patients, 127 (86.3 per cent.) showed draining sinuses. The sinuses developed usually during the first eight months after the onset of the first symptoms (Table III). Most of the patients came to the hospital for treatment soon after rupture of the abscess. In China, local needling and poultices are used commonly for all types of pain and inflammation, and therein probably lies the explanation for the relatively high incidence of sinus formation.

One or more associated lesions of active tuberculosis were found in 65 per cent. of the cases. The lungs were involved in 51 per cent.; the glands, in 17.8 per cent.; other bones, in 22.2 per cent.; and the intestines, the skin, and other tissues, in 11.1 per cent. These figures add emphasis to the fact that bone and joint tuberculosis is a secondary manifestation of a general disease in which the primary focus lies elsewhere. In this Clinic, from a careful study of the roentgenograms of the lungs of 100 patients with bone and joint tuberculosis (including various bones and joints), Meng and Chen found intrathoracic tuberculous lesions of varying degree in 78 per cent. of the cases. Under the term "intrathoracic lesions of varying degree", they included not only active parenchymatous lesions, but also all chronic and healed lesions of the lungs and tracheobronchial

TABLE IV

ANALYSIS OF RESULTS OF TREATMENT

Age (*Years*)	Type of Treatment Instituted	No. of Cases	Results							
			Good		Fair		Poor		?	
			No.	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*
1 to 16	Conservative treatment alone	4	1	25.0	3	75.0	0	0.0	0	0.0
	Curettage	21	5	23.7	6	28.6	9	42.9	1	4.8
	Local excision or amputation	21	17	80.9	1	4.8	3	14.3	0	0.0
	Total	46	23	50.0	10	21.7	12	26.1	1	2.2
16 to 60	Conservative treatment alone	1	1	100.0	0	0.0	0	0.0	0	0.0
	Curettage	22	3	13.6	7	31.8	11	50.0	1	4.6
	Local excision or amputation	60	50	83.3	1	1.7	9	15.0	0	0.0
	Total	83	54	65.1	8	9.6	20	24.1	1	1.2

lymph glands. In their group of 100 patients, active parenchymatous lesions were found in 47 per cent. of the cases.

In Table IV, the results of treatment are classified as follows: *good*, indicating local cure; *fair*, meaning apparent or almost complete local cure; *poor*, signifying no improvement, or progressive destruction of bone or dissemination of the tuberculous process; and *questionable*, indicating undetermined conclusions because of incomplete follow-up.

Only four of the patients from one to sixteen years of age and only one of the eighty-three patients aged sixteen or more years received conservative treatment alone. In the remainder of both groups, operative treatment was indicated because of the poor social or economic conditions and because of the advanced stage of the local disease.

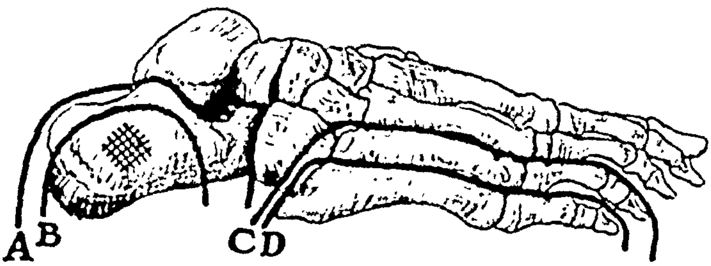

Fig. 1

Illustration showing lines of excision of bones: *A* or *B* used for complete or partial removal of the os calcis; and *D* and *C*, for removal of the fifth metatarsal or the fourth and fifth metatarsals.

The operative treatment of both the young and the adult patients was essentially the same. In an attempt to find the best method of operative attack upon this disease, various procedures were used.

1. *Curettage:* Experience with the curetting operation was extremely discouraging, since most of the patients treated in this manner developed persistent draining sinuses and the disease continued to progress locally. This was found to occur not only in the isolated lesions, but also in the more extensive lesions of several bones. Consequently, after trial in forty-three cases, the method was abandoned.

2. *Excision:* Our attention was directed to the excision procedure by the results which were being obtained by Dr. Van Allen and his coworkers* in the treatment of tuberculosis of the rib. They excised the diseased ribs, the surrounding periosteum, and all involved soft tissues (including the sinus tracts, together with a margin of healthy tissue). The tissues were excised in much the same manner as would have been done in the case of a neoplasm, and, when the excision was complete, recurrence was not seen. The same principles of treatment were employed in twenty-

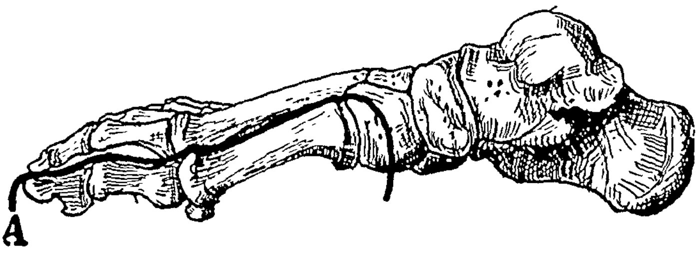

Fig. 2

Line *A* shows plane of excision for tuberculosis of the first metatarsal. Similarly, both the first and second metatarsals and toes may be removed.

* Unpublished work.

two cases of tuberculosis of the foot. In the cases with involvement of the toes alone, amputation was required and, in cases of involvement of the metatarsal or tarsal bones, complete excision of all of the area was necessary, even at the expense of removal of one-fourth or even one-half or more of the soft and bony structures of the foot.

In Figures 1, 2, 3, and 4 are sketched the various lines of excision as they concern the bones. Following the excision procedure in the patients with external sinuses, the wounds were closed in the usual manner. In the patients with draining sinuses and secondary infections, the raw surfaces of the wounds were covered with iodoform gauze and plaster-of-Paris casts were applied. After several days, openings were made in the casts, the iodoform packs were removed, and the surfaces of the granulation tissues were treated with Dakin's solution. As soon as the granulation tissue appeared healthy, Reverdin or Thiersch skin grafts were applied. If the wound continued to drain or to show evidence of further tuberculous infection, another excision operation was performed. In several cases, this procedure was repeated at intervals until a healthy surface was obtained for grafting. It is not possible to describe in detail the technique used in the individual cases, since every conceivable form of involvement of bone and soft tissue of the foot was encountered. Briefly, the excision method consisted of one or more operations until we felt satisfied that all of the tuberculous tissue was removed,—procedures which demanded slow and careful dissection of the soft tissues, with attempts to preserve the nerve supply. Technically, the excision operation is not particularly difficult. General anaesthesia is rarely necessary except in children. The danger of dissemination of tuberculosis is slight, and the wounds usually heal *per primum* or may be grafted with skin after two to five weeks. A patient with tuberculosis of the foot and without associated tuberculous lesions, once considered an invalid, may often again become a useful member of society in a few weeks' time. When associated lesions

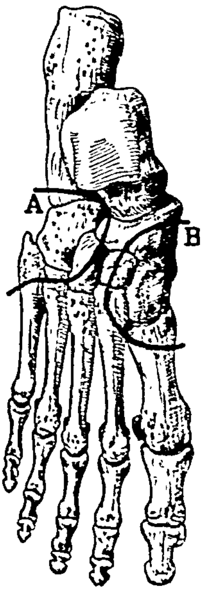

FIG. 3

B and *A* represent the lines of excision for isolated lesions of the internal cuneiform and cuboid bones. Portions of the surrounding normal bones are also excised, leaving a healthy surface for healing.

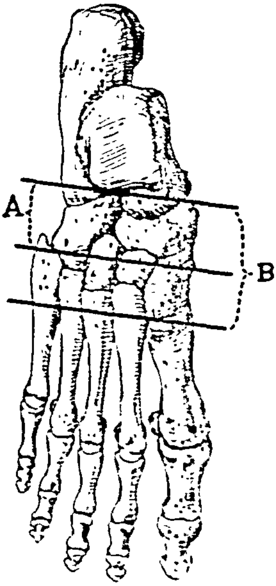

FIG. 4

Diagrammatic representation of the lines of excision used in tuberculosis of the anterior tarsal bones (after Ollier). The resection may include only Chopart's joint (*A*) or it may also include Lisfranc's joint (*B*).

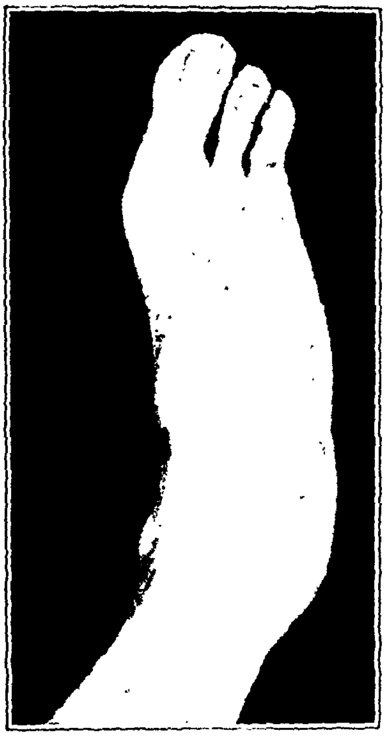

FIG. 5

Photograph showing a cured case after excision of the cuboid, and the fourth and fifth metatarsal bones and toes. The diseased soft tissue also was excised.

FIG. 6

Photograph of a foot of a patient cured after resection of diseased soft tissue and bones, including the internal cuneiform, the first metatarsal bones, and the great toe.

are present, the patients are treated in the same way. We have observed repeatedly that the eradication of an advanced peripheral focus of tuberculosis allows more rapid healing of the primary lesion. The loss of part of the foot or even of the foot and part of the leg may terrify the laity, but such apprehension usually disappears when the patient sees other individuals walking about with well-fitting prostheses or artificial limbs.

INDICATIONS FOR AMPUTATION AND SURGICAL EXCISION

It is difficult to set down definite indications for the various types of surgical treatment, because of the great variation in the activity and extent of the disease. However, in general, our present plan of management may be summarized as follows:

1. Amputation through the leg is reserved for the most advanced cases in which the disease is wide-spread in the tarsal or metatarsal bones and surrounding soft tissues. Isolated lesions of the toes are usually treated by amputation. Occasionally, amputation is performed in cases with less extensive involvement (cases which might be cured by local excision of the tuberculous area). In such cases, this procedure is indicated chiefly because the economic condition of the patient is such that he is forced to return to a gainful occupation in the shortest possible period of time.

2. Excision is indicated in any case in which the disease is localized sufficiently, so that, even though the diseased area is removed entirely, a useful portion of the foot will remain. Thus astragalectomy, calcaneoectomy, or removal of the fifth metatarsal or fourth and fifth metatarsals and toes (with or without the cuboid) may be performed (Fig. 1). After complete removal of the calcaneum, the Achilles tendon should be fastened to the posterior-inferior surface of the astragalus (Miltner and

Wan). The first metatarsal or even the first and second metatarsals and toes may be removed and the remaining portion of the foot may be quite satisfactory for ordinary use (Fig. 2). For single localized lesions of the smaller tarsal bones, the excision operation is particularly applicable (Fig. 3). The Ollier anterior tarsectomy (Fig. 4) is another form of excision operation which may effect a cure in extensive lesions of that area.

CONCLUSIONS

In advanced cases of tuberculous lesions of the bones and soft tissues of the foot, amputation through the leg is advised.

Treatment by careful surgical excision has proved to be an excellent method of management for advanced local lesions, especially those in adult patients. By this means, it is often possible to eradicate entirely the local disease and to save a useful portion of the foot.

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ROENTGENOGRAPHIC FEATURES OF RHEUMATOID ARTHRITIS *

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The term "rheumatoid arthritis" as used in this article is that form of multiple arthritis which typically begins before the age of thirty-five and tends to loss of cartilage and bone at the joints, deformity and eventual ankylosis, emaciation of the patient, elevation of the sedimentation rate of the blood, and positive response to the streptococcus agglutination test.

The roentgenographic features which characterize this disease and which are helpful in diagnosis are the subject of this discussion.

ROENTGENOGRAPHIC EXAMINATION

Roentgenograms for the detection of rheumatoid arthritis should depict the soft-tissue shadows as clearly as the bone shadows. In rheumatoid arthritis, particularly in the early stages, there are changes in the soft tissues at the joints and changes in the relative density of bone and soft tissues which are important and which can be detected only if the soft tissues are clearly pictured.

Examination should not be confined to a single joint. Rheumatoid arthritis is a systemic disease. Its diffuse manifestations may not be appreciated if examination is not extensive. Also, the joint of which the patient complains may not be the joint which is most characteristic of the disease roentgenographically. For these reasons, it is recommended that the hands, feet, knees, and lumbar spine be examined in every case in which doubt as to the diagnosis exists, regardless of the presence or absence of clinical evidence of disease in the regions mentioned.

EARLY MANIFESTATIONS

Rheumatoid arthritis is generally accompanied by a decrease in the calcareous density of the bones, which is most readily noted in the hands and feet. The bones are not as dense as they should be at the age of the patient: they appear too old for the patient. The whole of each bone is affected, although the change is not as readily noticeable in the cortical as in the cancellous areas. This systemic decrease in bone density may be the earliest roentgenographic manifestation of the disease. The few patients who do not reveal this decalcification are usually those in whom the disease developed late in life or who previously had had gonorrhoea.

An early feature in rheumatoid arthritis is the development of a soft-tissue mass at the joint, which we shall call an effusion, although it may in fact represent effusion, granulations, or synovial thickening. The pres-

* Read before The American Society for the Study of Arthritis, New York City, December 13, 1935.

ence of such effusion is evidenced by displacement or replacement of fat pads at a joint by a more dense soft-tissue mass, or by distention of the capsule at a joint, or by displacement of adjacent muscle outlines away from a joint. At the joints of the phalanges such an effusion may be highly characteristic of rheumatoid arthritis in that the effusion is definitely fusiform in shape, with the fusiform shadow symmetrically centered on the joint. Such a characteristic shadow may be demonstrable in the hands even when the joint complained of is elsewhere.

LATER MANIFESTATIONS

As rheumatoid arthritis advances, some loss of bone substance may appear. This has a certain specific character which we may describe as small punched-out areas of atrophic loss of substance at the junction of bone and cartilage. By the term "punched-out" we mean that the bone is lacking as if removed with a punch—the area of bone loss is rounded and there is no reaction in the adjacent bone; that is to say, there is no condensation in the bone texture and no haziness or smokiness due to soft-tissue reactions within the bone. When the lesion subsides and repair occurs, a thin line of dense bone may form on the surface of the area of loss of substance, but this is not to be confused with the wide condensation area or other changes indicative of reaction about the lesion which distinguish other forms of bone destruction from punched-out areas of atrophic loss of substance.

Other manifestations of the disease which may appear are thinning of the cartilaginous joint space, ankylosis, and, in repair, calcareous lipping at the margins of the joint. These changes, however, are not often useful in differential diagnosis.

DIFFERENTIAL DIAGNOSIS

Osteo-Arthritis

Osteo-arthritis does not produce lack of density of the bones beyond what is consistent with the age of the patient. It does not tend to produce effusion, particularly fusiform effusion, at the small joints. Osteo-arthritis produces calcareous lipping at the joint margins, which may be simulated by reparative calcifications in rheumatoid arthritis, but osteo-arthritis does not produce the punched-out areas of loss of substance which are usually present in rheumatoid arthritis when reparative lipping is present, and the underlying bony joint surfaces are comparatively normal in most cases of osteo-arthritis but frequently irregular in rheumatoid arthritis. When there is doubt as to the nature of the lesion, extensive examination should settle the question; usually some joint somewhere can be found that is typical of one condition or the other. Not infrequently both conditions are present in the one patient.

Gout

Punched-out areas of atrophic loss of substance occur in gout as in rheumatoid arthritis, but gout does not cause systemic loss of bone

density beyond that consistent with the age of the patient. In gout, the effusion does not tend to be fusiform and centered on the joint, but is more spherical or oval and is eccentrically placed: often it is centered on an area of loss of substance instead of on the joint. In acute gout, there may be marked diffuse swelling about the joint, but such swelling beyond the confines of the joint capsule is never a prominent feature of rheumatoid arthritis.

Atrophic Arthritis of the Toes Following Gonorrhoea

This condition is possibly a special type of rheumatoid arthritis. It is not a gonococcic infection of the joints in the usual sense. The metatarsophalangeal joints are involved. Characteristically, the involvement is multiple. The metatarsal heads reveal atrophic loss of substance which may be very marked, but there is no visible effusion as would be present in the ordinary rheumatoid arthritis. Some bone has been lost and that constitutes the whole of the local lesion. The bones are usually as dense as they should be for the age of the patient. The patients with this condition usually have spurs of post-gonorrhoeal type on the plantar angle of the heel,—that is, the spurs are very uneven in outline and density and do not present the clear osseous structure which is usually present in spurs of other types, such as those occurring in osteo-arthritis.

The Specific Infections

Rheumatoid arthritis may cause decreased density of the bones with the right and left sides similarly affected, but it does not cause unilateral variations in density. Hence, if the bone density is different on the two sides, the difference is not due to rheumatoid arthritis. This fact alone will serve to distinguish most instances of specific infectious lesions, such as tuberculosis, pyogenic infection, gonococcic infection, and some syphilitic lesions.

Rheumatoid arthritis does not cause exuberant calcareous productive reaction or dense subperiosteal calcification, such as often occurs in pyogenic and syphilitic lesions.

Destruction that occurs in specific infectious lesions differs from the punched-out areas of loss of substance of rheumatoid arthritis in that the involved areas tend to be larger, the adjacent bone varies from normal density, and the margins are irregular and appear eroded instead of punched-out.

Lesions in the Spine

In the spine, the characteristics of rheumatoid arthritis which we have emphasized are not often seen, as the mass of tissue is so great that slight changes are obscured. Rheumatoid arthritis in the spine (Marie-Strümpell arthritis) tends to slurring or lack of clearness of the articular facets, irregular depressions in the articular surfaces of the facets, and ankylosis through the ligamentous structures without loss of the [illegible]

When the spine is affected, the extremities should also be examined if the diagnosis is questionable.

Osteo-arthritis in the spine develops calcareous lipping or osteophytic formation at the margins of the joints, particularly at the margins of the bodies. It does not tend to ankylosis except when the osteophytes are excessively exuberant.

Neither rheumatoid arthritis nor osteo-arthritis presents destructive lesions of the vertebral bodies, and thinning of the vertebral discs in these diseases is accompanied by definite osteophytic formation or by ankylosis. They do not produce abscesses.

By these means the specific infectious lesions in the spine are readily differentiated.

SUMMARY

Roentgenograms for the study of rheumatoid arthritis should display the soft-tissue shadows as clearly as the bone shadows.

The hands, feet, knees, and lumbar spine should be included in the examination.

The roentgenographic features most useful in the diagnosis of rheumatoid arthritis are systemic decalcification of the bones, fusiform effusion symmetrically centered on the joints (particularly the joints of the phalanges), and punched-out areas of atrophic loss of bone substance at the junction of cartilage and bone.

FRACTURE OF THE LATERAL CONDYLE OF THE HUMERUS IN CHILDHOOD *

BY PHILIP D. WILSON, M.D., NEW YORK, N. Y.

Judging by the lamentable late results of fracture of the lateral condyle of the humerus in children, which are encountered each year in our orthopaedic clinics, one may say without charge of unfairness that the medical profession has failed as yet to grasp the importance of this pathological lesion. Yet there is little excuse for this lack of understanding, because the injury is one of the most characteristic of all the fractures in the region of the elbow, and much has been written in regard to it. The most probable explanation is that many physicians do not comprehend the true nature of the pathology and depend upon the remarkable healing and restorative powers possessed by children to accomplish more than is possible under the circumstances. Also, this is one of the less common fractures of the elbow and physicians may not encounter it frequently enough to be able to differentiate it and put it in a class apart from other injuries of the lower end of the humerus. Whether these reasons are correct or not, it is true that this fracture seems to escape recognition and to receive less satisfactory treatment than almost any other fracture of the elbow.

FREQUENCY

Massart and Cabouat[4] estimated that fractures of the lateral condyle constituted one-third of all the fractures of the lower end of the humerus, but this figure is entirely too high in the author's opinion. In a previous analysis of 439 fractures and dislocations of the elbow[5], the writer found eleven examples of this fracture, or 2.5 per cent. Fracture of the lateral condyle represented nearly 6 per cent. of the 189 fractures of the lower end of the humerus, but only about 0.2 per cent. of the total number of 4,536 fractures and dislocations treated.

AGE

The fracture occurs within a fairly narrow age range, and this is necessarily so, because of the epiphyseal ossification of the lower end of the humerus, which plays an important rôle in determining the nature of this fracture. Of the patients seen by the author, the youngest at the time of the injury was three years old and the oldest was thirteen years of age. The surgeon frequently encounters the lesion in adults, but, in such cases, he is dealing with the late results of the injury and, upon inquiry, will find that the fracture originated in early childhood.

* Read at the Annual Meeting of the [illegible] Orthopaedic Surgeons, St. Louis, Missouri, January 17, [illegible]

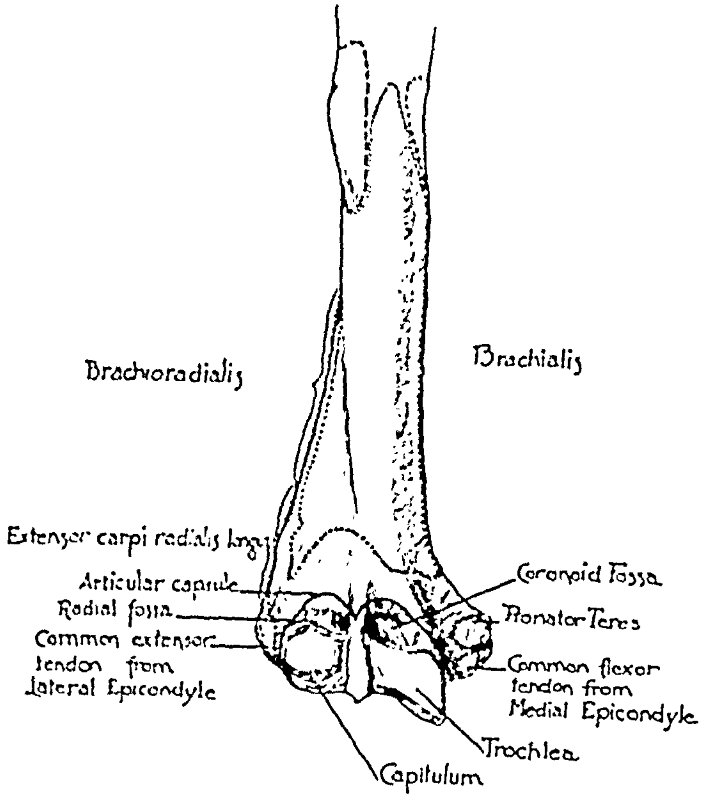


FIG. 1

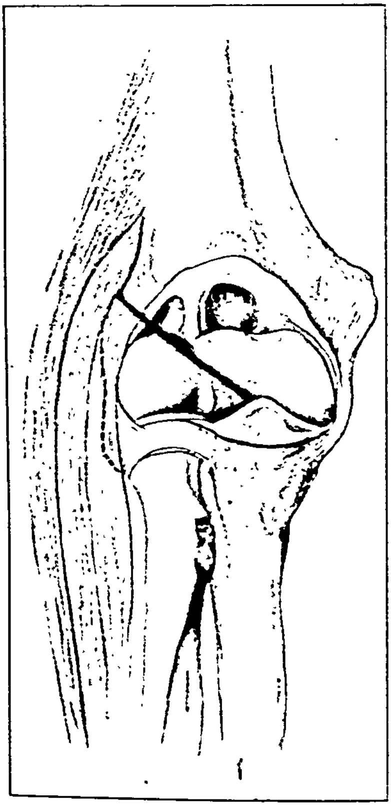
Drawing of the lower end of the humerus, showing the muscle attachments.

PATHOLOGY

The injury consists of a fracture starting at the lateral side of the lower end of the humerus, at a point from about one-quarter of an inch to one-half an inch above the epiphyseal line of the capitellum, and extending obliquely inward and downward to the region of the trochlea, where it breaks through the articular cartilage into the elbow joint, thus separating a triangular fragment with a diameter of from one inch to one and one-half inches and consisting of the capitellar epiphysis and a fragment of the metaphysis. Through a part of its course, the line of fracture may correspond with the epiphyseal line, but invariably a thin plaque of bone is detached from the metaphysis, chiefly from the lateral border and the posterior surface.

The displacement is of variable amount; its complete form consists of a rotary dislocation outward and backward of the condylar fragment. The arc of rotation of the horizontal axis of the fragment may be 90 degrees or more. The articular surface thus faces medially and upward instead of downward. This displacement is due to the contraction of the long extensor muscles of the wrist and fingers, which take their origin by means of a common tendon from the lateral condyle of the humerus. The brachioradialis originates from the humerus at a higher level and, therefore, is not involved. At operation, the author has found these long extensor muscles stripped away from the lateral surface of the humerus, but retaining their attachment to the condylar fragment. There is generally a transverse tear in the muscular aponeurosis, from one-half an inch to one inch in width, directly overlying the condyle. The lateral ligament of the elbow retains its attachment to the condylar fragment and provides a hinge upon which the fragment rotates.

The degree of rotary displacement is probably governed by the width of the tear in the muscular aponeurosis, since the ability of the muscles to pull the lateral border of the condylar fragment downward



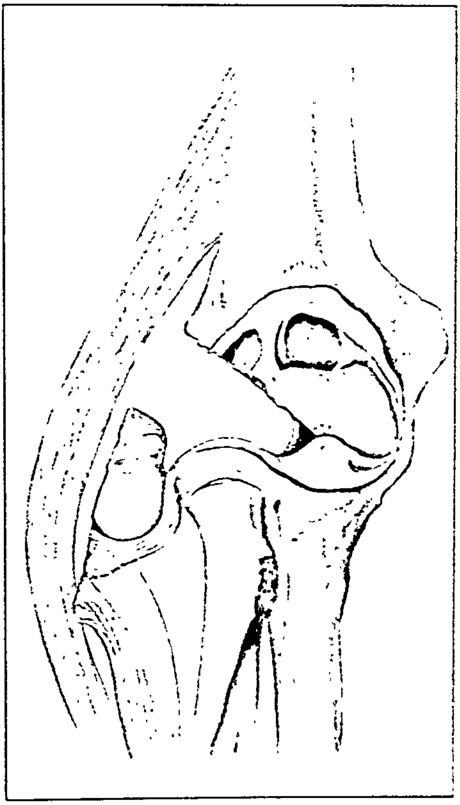


FIG. 2-A FIG. 2-B

Schematic drawing illustrating fracture and rotary displacement of the lateral condyle of the humerus.

Fig. 2-A: Showing line of fracture in relation to muscular and ligamentous attachments.

Fig. 2-B: Showing rotary displacement, due to pull through the common tendon of the extensor muscles and limiting action of the lateral ligament.

depends upon the extent to which they are freed from the adjacent muscles. In every case, the intact lateral ligament limits the displacement. When the displacement is of the incomplete type, it is probable that the overlying muscular aponeurosis has remained intact. In such cases, the condylar fragment is displaced laterally and somewhat posteriorly, but is not rotated upon its horizontal axis. Another element commonly present in the displacement is axial torsion, as a result of which the lateral margin of the fragment is carried posteriorly and the mesial border is brought forward.

The essential point to be emphasized in a case of rotary displacement is that the fractured surface of the condylar fragment is carried away from any contact with its opposing surface on the lower end of the humeral shaft and that in its place is substituted the smooth articular cartilage of the inferior surface of the fragment. Under these circumstances, healing by bony union is impossible and pseudarthrosis invariably results. As long ago as 1825, Sir Astley Cooper reported that he had studied two

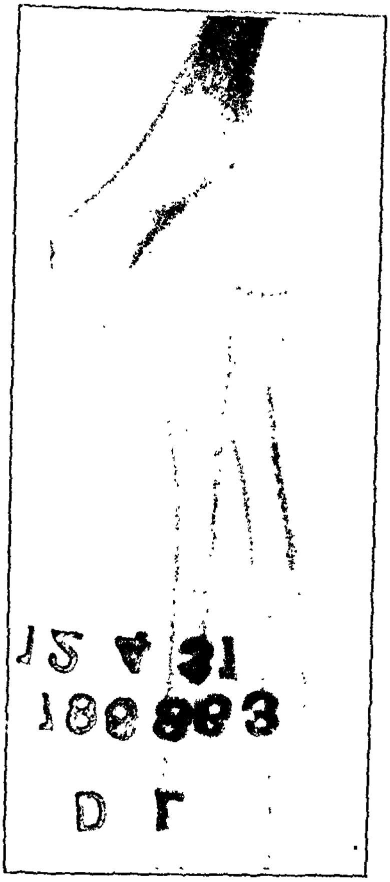


FIG. 3

Ununited fracture of the lateral condyle of the humerus in a child of fifteen years, eight years after injury.

gross specimens of this type of fracture which showed only ligamentous union. He stated "If the whole extent of the fracture be within the ligament it does not, so far as I have seen, unite by bone whatever may be the means employed." He evidently assumed that there was interference with the nutrition of the bony fragment. Massart and Cabouat[4] fell into the same error and assumed that interruption of the blood supply to the condylar fragment accounted for the frequency of non-union. However, from a study of old cases with non-union, it is obvious that this is incorrect, because it will invariably be seen that the condylar fragment has increased in size and that the epiphysis has continued to function after the fracture. Furthermore, at operation it can be demonstrated that the condylar fragment retains sufficient ligamentous and muscular attachments to permit blood to reach it through the epiphyseal and metaphyseal vessels. Additional evidence, showing that the loose fragment receives ample nutrition, is furnished by the fact that when the latter is replaced, so that the fractured surfaces are brought into contact, healing by bony union proceeds promptly. From these facts, we may conclude that failure of bony union is always the result of wide separation of the fractured surfaces and that, if the displacement is corrected, bony healing may be expected in all cases.

MECHANISM OF INJURY

The cause of the injury is usually a fall, but it is generally impossible to ascertain from the patient's story whether the force was transmitted through the outstretched hand or received directly upon the elbow. In discussing this point, Stimson[6] stated: "I have found it easy to produce the fracture by adduction of the extended forearm in bodies of the young, or by a blow upon the palm with the elbow flexed at a right angle." From a consideration of the nature of the lesion, one would conclude that indirect trauma played the major rôle and that the mechanism was generally adduction of the forearm upon the humerus, with the elbow incompletely extended, thus causing strain upon the external lateral ligament and evulsion of the condyle. This would account for the tear in the overlying muscular aponeurosis and the rotary dislocation of the fragment outward and backward as a result of muscle pull. It is probable that in the cases with incomplete displacement and absence of rotary

deformity the fractures are produced by a force transmitted directly upward through the radius to the capitellum from a fall upon the outstretched hand.

EPIPHYSEAL DEVELOPMENT

Cohn[2], in describing the epiphyseal development and ossification of the lower end of the humerus, stated that the capitellar epiphysis is the first to appear and may be recognized as early as from seventeen months to two years. The epiphysis of the internal epicondyle appears at about seven years, but always remains separate from the lower humeral epiphysis and unites with the shaft directly. There may be two separate centers for the trochlea, or only one, and these usually make their appearance at about the eighth to the tenth year. A separate center for the external epicondyle is the exception rather than the rule. By the age of ten years, the capitellar epiphysis has broadened considerably and occupies approximately half of the base of the humeral shaft, from the middle outward. In the lateral view, the epiphysis lies anterior to the axis of the shaft, giving somewhat the appearance of a short-ended hockey stick. The capitellar epiphysis fuses with the trochlear epiphysis from the age of eleven to thirteen years, and shortly after-

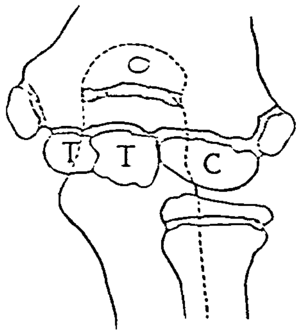


Fig. 4

Drawing from illustration of Camp and Cilley [1] showing ossification of the lower end of the humerus. According to Cohn[2], the capitellar epiphysis appears at seventeen months and fuses with the trochlear epiphysis at from eleven to thirteen years; the combined epiphysis unites with the shaft at from thirteen to fourteen years.

Fig. 5-A Fig. 5-B

Ununited fracture of the lateral c[illegible] of the [illegible] [illegible] developed at age of forty-[illegible] years [illegible]

ward the entire epiphysis unites with the shaft, generally at about the age of thirteen to fourteen years.

True epiphyseal displacement of the lower end of the humerus almost never occurs, and there was no example of such an injury in over 500 cases of fracture or dislocation of the elbow that were studied by the author. The reason for this is clear. The various bony centers do not become fused together, so that separation as a single unit becomes possible, until the age of thirteen, and at this time union of the epiphysis with the shaft is so far advanced that fracture is more easily produced than epiphyseal displacement.

Fracture of the lateral condyle and capitellar epiphysis takes the place of epiphyseal separation of the lower end of the humerus, and is its equivalent. It occurs from the age of three to thirteen years. During this period, the capitellar epiphysis is the only existing osseous center, with the exception of the internal epicondyle, which is much more an apophysis than an epiphysis. The reasons why the fracture of the lateral condyle is rarely entirely epiphyseal are that the capitellar epiphysis is entirely intracapsular and that the ligaments of the elbow through which strain may be exerted are attached to the metaphysis. When force is transmitted upward through the radius to the capitellum, the elbow is always in incomplete extension; in this position, as a result of the forward projection of the lower articular end of the humerus, the epiphysis is buttressed posteriorly by the metaphysis, which must be fractured if the capitellum is displaced. The author has seen pure epiphyseal fracture of the capitellum as a complication of dislocation of the elbow in the young, but even then such an injury is exceedingly rare.

The upper age limit for fracture of the lateral condyle in children is about thirteen years, at which time the capitellar epiphysis fuses with the trochlear epiphyses, to be followed shortly afterward by union of the entire epiphysis with the shaft.

LATE COMPLICATIONS

The frequency of late complications of ununited fracture of the lateral condyle of the humerus in children is notorious. Due to a separation of the important capitellar growth center, the lower end of the humerus develops irregularly. The mesial half grows normally, due to the undamaged state of the trochlear epiphyses, while the lateral portion is deprived of its normal growth increment. Since many of the fractures occur at as early a period as from three to five years of age, it is apparent that a very considerable irregularity of growth can result before the trochlear epiphyses become fused with the shaft. The plane of the lower articular surface of the humerus changes gradually from horizontal to oblique, sloping upward and outward, and there is an increasing degree of cubitus valgus deformity. This may cause a very conspicuous alteration in the alignment of the elbow.

In spite of the ununited condylar fragment, the function of the elbow

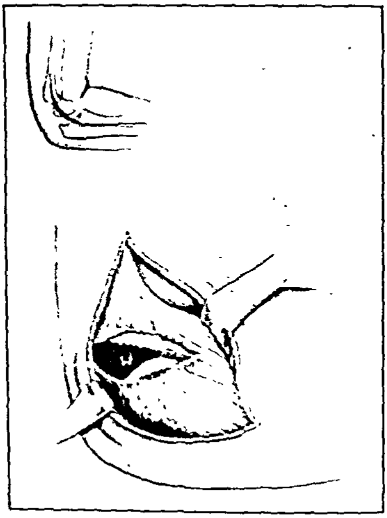


FIG. 6-A

Appearance of tear in muscular aponeurosis and displacement of fragment seen at operation. The fractured surface of the fragment faces outward.

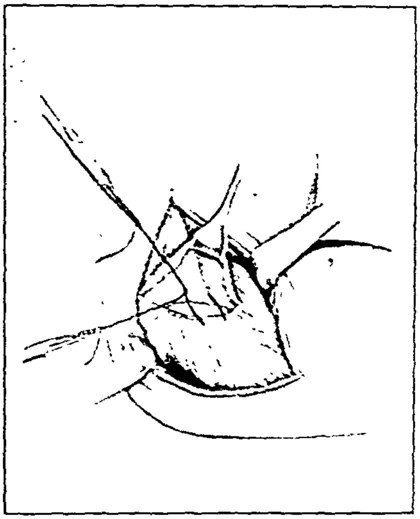


FIG. 6-B

Method of fixing fragment by silk suture passed through ligamentous attachments to lateral condyle and drill hole in distal end of fragment of shaft.

joint continues surprisingly good. The patients have but little pain, and when they are brought to the hospital it is because of the deformity of the elbow rather than because of any disability. Upon examination, a certain amount of crepitation can be detected in the elbow, and sometimes movement of the loose fragment can be demonstrated. Generally there is nearly a full range of flexion and extension, and pronation and supination are complete. The patients may complain of weakness of the arm, but the writer has seen some who were capable of performing heavy laborious work without ill effects.

Delayed ulnar-nerve palsy is a very common late result of ununited fracture of the lateral condyle in children. Many instances of this condition have been reported, and, because of its frequency, this late complication has attracted more attention to fracture of the lateral condyle than the more immediate results. The symptoms of ulnar-nerve palsy develop gradually after an interval ranging from fifteen to fifty-five years. The patient notices a sensation of numbness in the ulnar-nerve distribution to the fingers and weakness and awkwardness in the finer movements of the hand. Examination reveals wasting of the interosseous muscles, weakness of the movements involving the muscles supplied by the ulnar nerve, and diminished sensation in the ulnar area of the fingers. The paralysis is generally incomplete. There is a marked cubitus-valgus deformity of the elbow and a history of injury in early childhood, and the roentgenographic examination discloses an old ununited fracture of the lateral condyle. Frequently, thickening and sensitiveness of the ulnar nerve can be demonstrated in the groove behind the internal epicondyle. The ulnar palsy is due to a localized pressure neuritis caused by the [illegible]

Fig. 7-A

Case F. V., aged six years. Fracture of lateral condyle with incomplete displacement. Before operation.

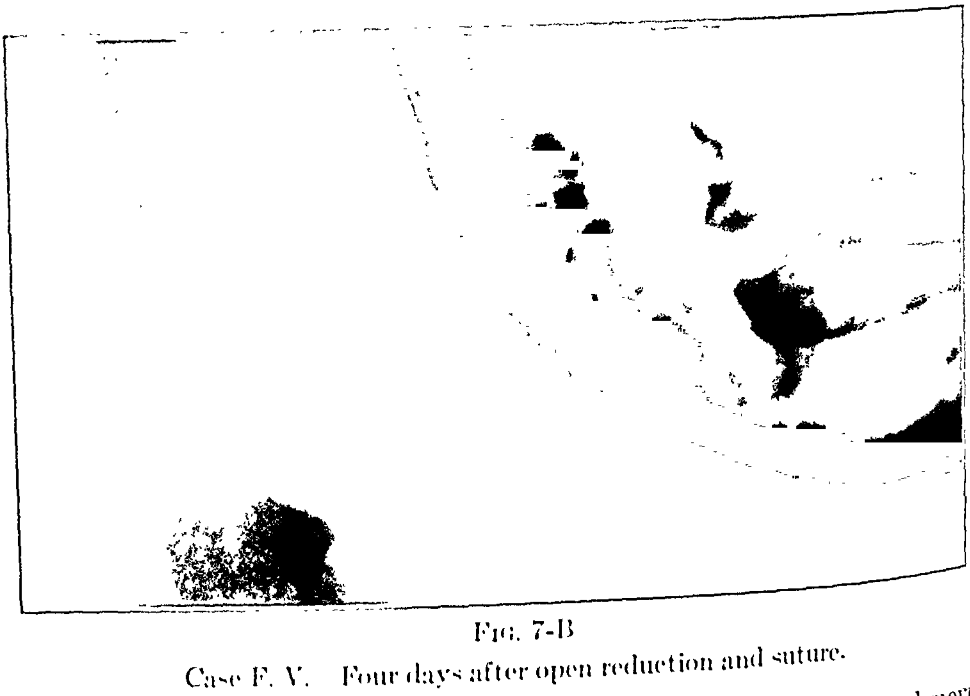


Fig. 7-B

Case F. V. Four days after open reduction and suture.

of the nerve, due to the increasing cubitus valgus deformity and movement of the elbow. The condition can be completely relieved by operative transposition of the ulnar nerve to the front of the elbow.

DIAGNOSIS

The diagnosis of fracture of the lateral condyle can generally be made at the time of injury by careful clinical examination. The swelling and ecchymosis are confined chiefly to the lateral portion of the elbow joint, and the tenderness is also localized in this region. Supracondylar fracture can be ruled out by the absence of the characteristic deformity, and frac-

ture of the upper end of the radius can be eliminated by the free mobility in pronation and supination. There is, however, no necessity for any manipulation that may cause pain, since the chief reliance must be placed

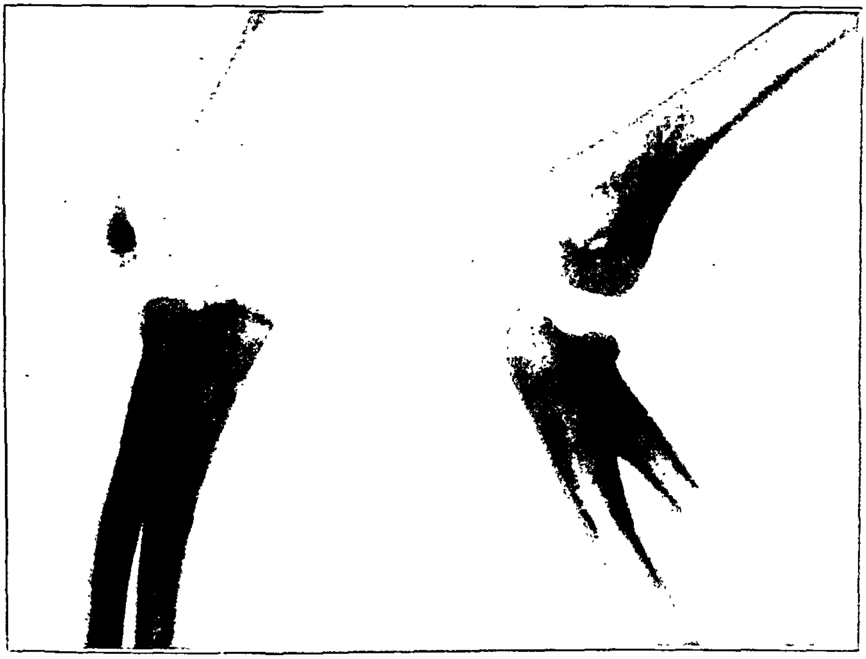


FIG. 8-A

Case J. V., aged six years. Fracture with complete rotary displacement and torsion. Before operation. (Case of Dr. E. A. Van Derwerker.)

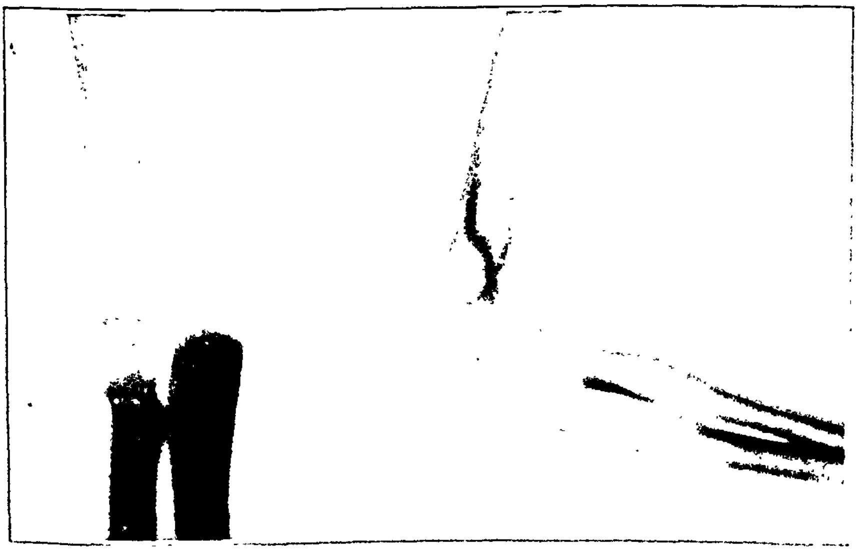


FIG. 8-B

Case J. V. Three weeks after operation [illegible]

FIG. 9-A

Case H. V., aged five and one-half years. Fracture with complete rotary displacement. Before operation. (Case of Dr. Fenwick Beekman.)

FIG. 9-B

Case H. V. Following operative reduction and suture of torn muscles.

FIG. 10-A

Case A. H., aged five years. Fracture with incomplete type of displacement. Before operation.

FIG. 10-B

Case A. H. Three days after open reduction and suture. Complete reposition.

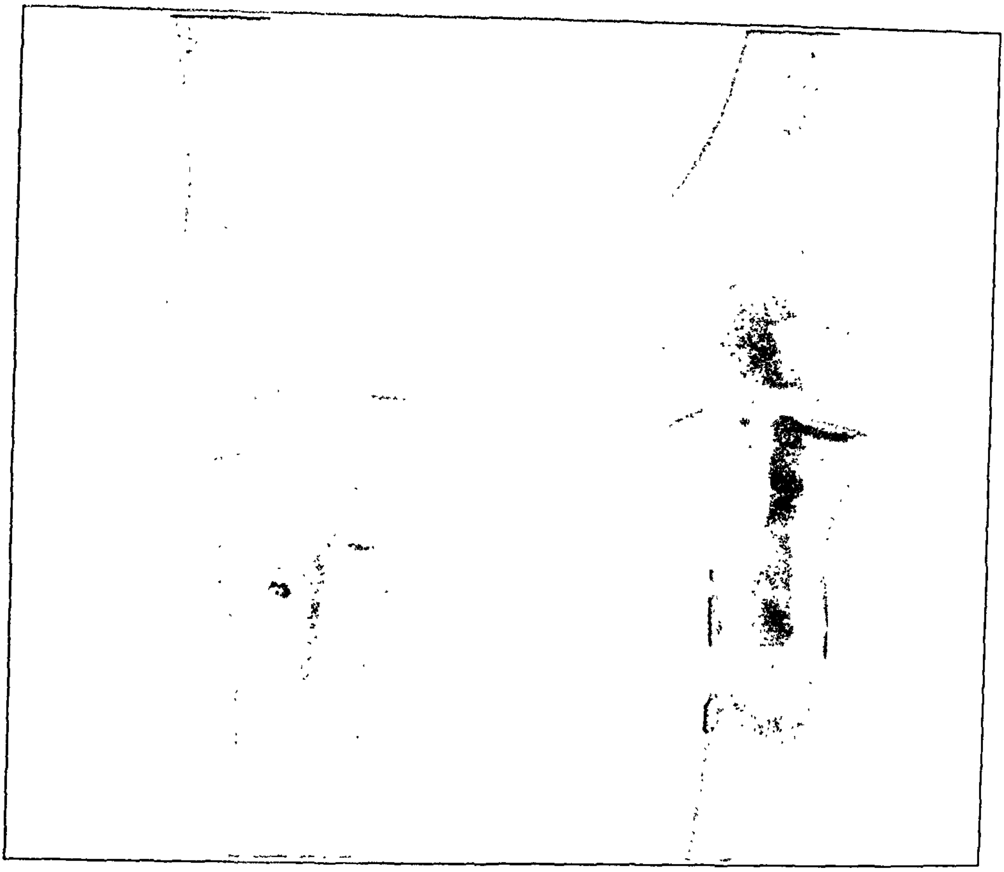


FIG. 11-A

Case L. Z., aged seven years. Fracture with incomplete displacement. Before operation.

FIG. 11-B

Case L. Z. Eighteen months after open reduction. Normal function and alignment.

upon the roentgenographic examination, which is always necessary before making a diagnosis.

There should be no difficulty in recognizing the fracture from inspection of the roentgenograms. The rotated displaced condylar fragment can be seen lying in the soft parts at some distance from its normal position. The chief enlightenment as to the condition is obtained from the roentgenogram made in the anteroposterior plane; the lateral view often fails to shed any additional light because of the superimposed shadows.

TREATMENT

In the cases with little or no displacement, simple splinting methods which fix the elbow in the position of acute flexion are sufficient. When displacement is present, however, operative reduction is almost invariably necessary and should be performed promptly. A rare case has been reported, in which a rotated fragment was replaced by closed manipulation, but this method fails so uniformly that the author considers it folly even to attempt it. When operation is performed within the first two or three days, replacement is accomplished easily and with a minimum of trauma. The fracture is exposed through a lateral incision. A forceps is applied to the muscles and ligaments attached to the lateral condyle and this is

pulled upward while, at the same time, the fragment is pressed forward into normal position with the fingers.

Surgical opinion differs as to the necessity of internal fixation of the fragment. Stone[7] and others have reported that, when replacement was obtained, they were able to hold the fragment in position by simply placing the elbow in the position of acute flexion. Other surgeons[5] have employed steel nails or pins. The author would not hesitate to use a pin if it were necessary, as is frequently the case when the operation is performed after a considerable interval. The disadvantage of a pin is that it transfixes the epiphyseal cartilage and is liable to cause disturbance of growth. For this reason, the writer much prefers to rely upon simple suture of the fragment with silk. It is possible to fix the suture securely to the condylar fragment by passing it through the ligamentous and muscular attachments. The distal end of the shaft is generally stripped bare of soft tissues, however; for this reason, a drill hole must be made in the external supracondylar ridge directly above the fracture line. When the other end of the suture is passed through this hole and tied, the fragment is securely fixed in position, and the surgeon is protected against the possibility of later displacement, which is always an unfortunate complication after open reduction. Following closure of the wound, a posterior plaster splint is applied with the elbow fixed in a position of moderate flexion.

Fixation of the elbow is maintained for a period of three to four weeks, depending upon the age of the child. At the end of this time, the splint is removed and the arm is protected by a sling for a period of one week or longer. Motion is permitted and encouraged after the removal of the splint, and, as a rule, active use can be allowed at the end of four to five weeks. Function is regained quickly, and normal alignment and function can be expected as the final result. The author has seen only one instance of interference with growth of the capitellar epiphysis in cases where union has been obtained with good position.

It needs to be emphasized that operative replacement of the condylar fragment becomes increasingly difficult with the lapse of time. The muscles causing the displacement become contracted and fixed in their new position. Granulation tissue grows in and fills the gap in the torn muscles. The normal anatomy becomes obscured, and, after two to three weeks, the matter of securing reduction, even by open operation, is a real problem. In such cases, it may be necessary to free some of the ligamentous and muscular attachments to the condylar fragment, but this involves sacrifice of the blood supply and may vitiate the result. In the author's opinion, excision of the condylar fragment, which is the easy alternative, ought never to be done except in the very late cases. The writer knows of a case (Fig. 13) in which operation was performed by Dr. W. A. Rogers as late as two years after the injury, and it was possible to freshen the fractured surfaces, to insert a bone graft between the end of the shaft and the condylar fragment, and, by solid fixation, to ...

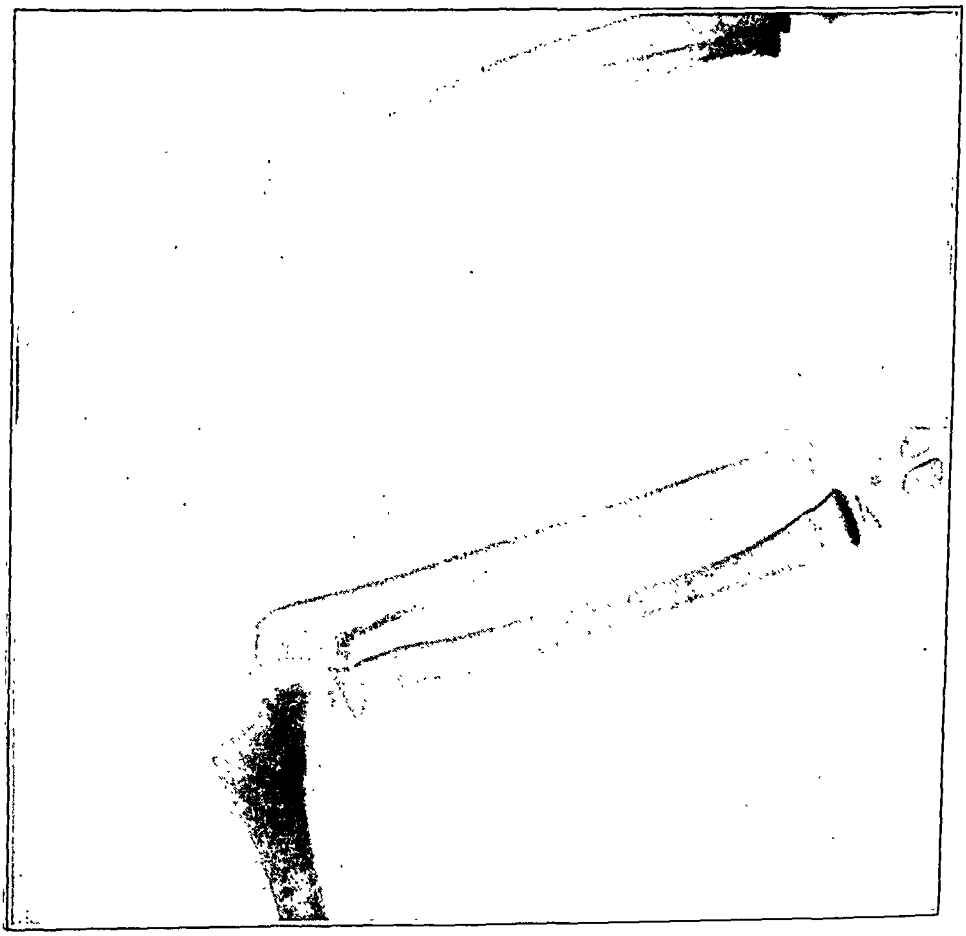


Fig. 12-A

Case D. F., aged three years. Fracture with complete rotary displacement. Before operation.

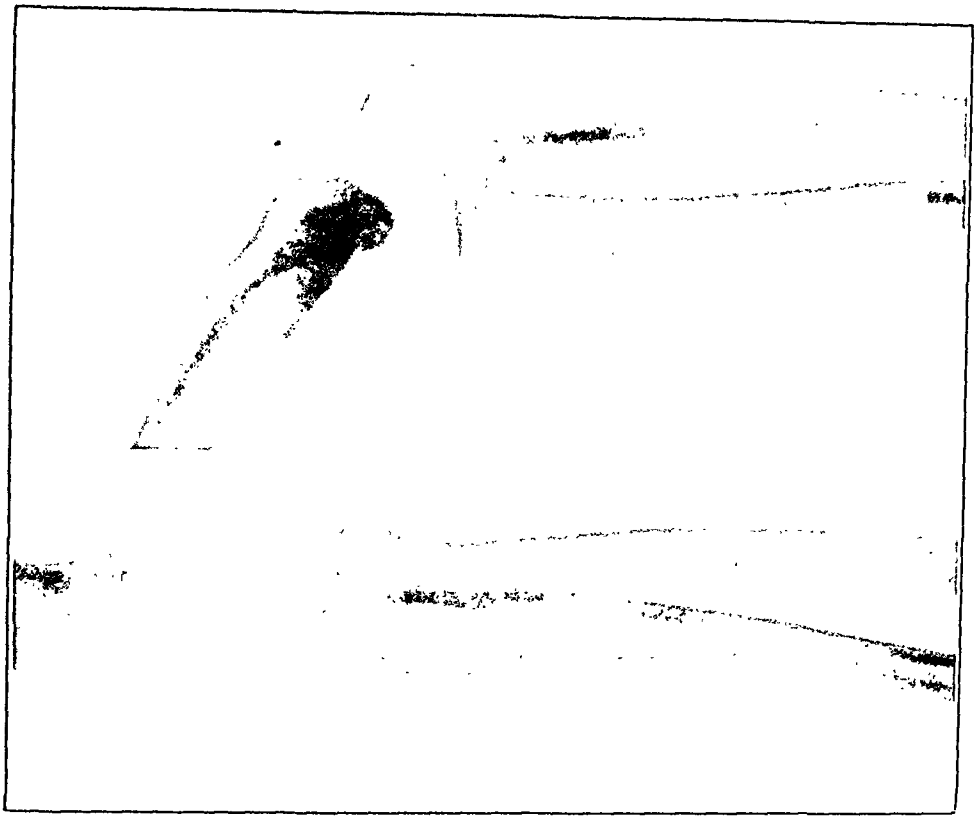
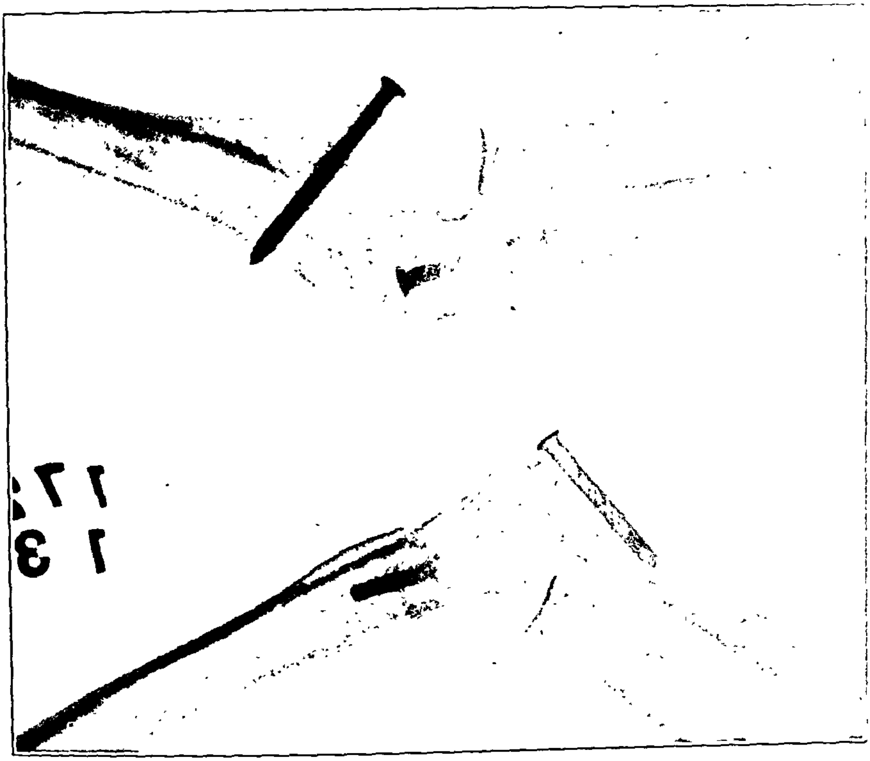


Fig. 12-B

Case D. F. One year after open reduction and suture.



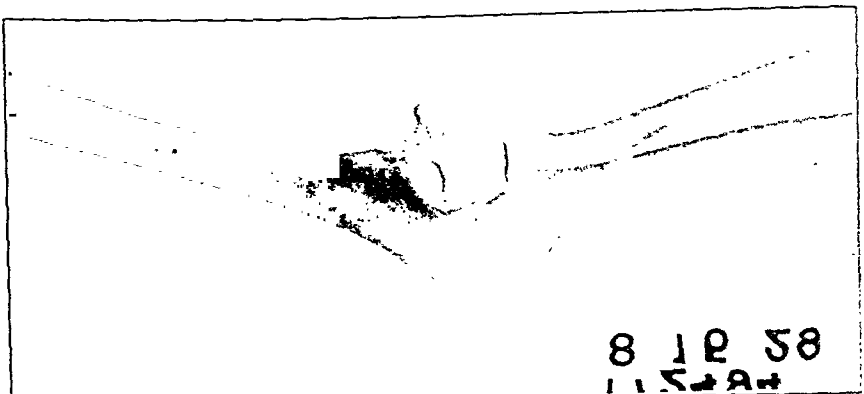


Fig. 13-A

Case B. P., aged seven years. Old ununited fracture of lateral condyle three years after injury. Roentgenogram taken at time of admission. (Case of Dr. W. A. Rogers.)

Fig. 13-B

Case B. P. Three years after operative reduction, insertion of bone graft, and fixation with long screw. Solid union and only slight deformity.

long screw, to obtain union. It seems to the author that a procedure of this type is preferable to excision, and that the subsequent deformity of the elbow, due to growth disturbance, will be much less than when the fragment is removed.

Correction of cubitus valgus deformity, resulting from failure of union of a fracture of the lateral condyle of the humerus in childhood, is frequently necessary. This requires a supracondylar osteotomy and excision of a bony wedge with a sufficient base at the medial border of the humerus to permit the plane of the lower articular end of the humerus to be brought into normal relation with the axis of the shaft. The writer has found it difficult to retain the fragments in alignment following such an operation and has adopted the procedure of fixing them with a steel bone plate in order to avoid postoperative displacement. Delayed ulnar-nerve palsy can be prevented by correction of the cubitus valgus deformity at an early age, and the possibility of this later complication is an additional reason for advising operation before nerve symptoms have developed.

CONCLUSIONS

Fracture of the lateral condyle of the humerus in children is a serious injury and, unless treated properly, results in failure of union, weakened function, marked cubitus valgus deformity, and delayed ulnar-nerve palsy. The condition of pseudarthrosis is due to the extreme rotary displacement of the condylar fragment and, in order to overcome this, operative reduction is necessary. Good approximation is followed by bony union, recovery of normal function, and absence of any later complications. It is important for physicians to learn to recognize this fracture in order that it may receive early surgical treatment.

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UNUNITED FRACTURES OF THE NECK OF THE FEMUR

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Generations of surgeons have recognized the difficulties met with in the treatment of fractures occurring in the femoral neck. The ingenuity of orthopaedic surgeons has been demonstrated by the widely different methods of treatment which they have advocated, and each of these methods has been successful in promoting bony union in a certain proportion of cases.

Only Whitman's method has been practised for a period sufficiently long to enable the majority of surgeons to understand its limitations, and, in spite of the most careful adherence to the method of choice, failures to obtain union are unavoidable. We are left then with the problem of the unstable hip. Normally the body weight is borne through the line of the sacro-iliac joint and the center of the acetabulum; in the presence of non-union, the support through the thigh is borne at least one and one-half inches to the outer side of this point, so that the center of body weight lies at an equal distance to the inner side. The only method by which the stability of the hip can be restored is by bringing the support again under the normal position of the center of the acetabulum. This may be accomplished by any one of three methods:

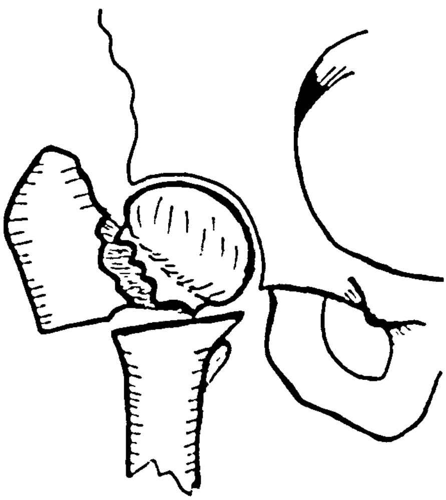

FIG. 1

Drawing from roentgenogram of old ununited fracture, showing absorption of neck, varus deformity, arthritis, line of section of modified Lorenz osteotomy, and displacement of lower fragment.

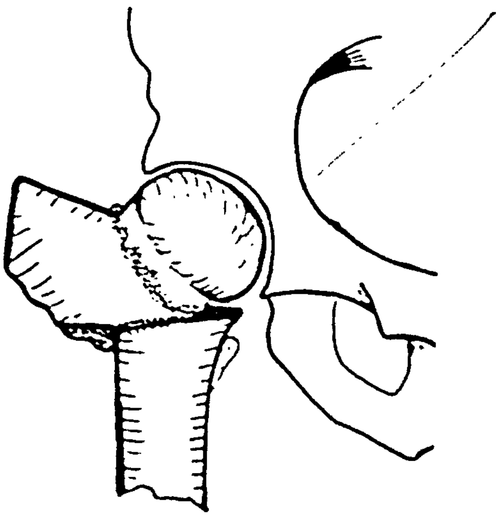

FIG. 2

Drawing from [illegible] of osteotomy [illegible] fracture, [illegible]

Fig. 3

Mrs. S., aged fifty-six years. Preoperative roentgenogram, eight months after accident.

Fig. 4

Mrs. S., aged fifty-six years. Lorenz osteotomy had been performed eight months after the accident. Roentgenogram taken one year later.

1. *Arthrodesis of the hip joint*—a very difficult procedure, entailing great operative risk, and usually resulting in failure.

2. *Reconstruction methods*, as suggested by Whitman and Brackett, in which the remainder of the neck is placed in the acetabulum, with or without removal of the head of the femur, and the greater trochanter is transplanted to a position further down the shaft.

3. *Bifurcation operation*, based on the suggestion of Lorenz, in which the shaft of the femur is transferred directly under the lower margin of the acetabulum and head of the femur.

The author has carried out this last method of treatment in twenty-seven cases of ununited fracture of the neck of the femur; the first of these operations was performed in 1926.

Fig. 5

Mrs. N., aged fifty-seven years. Lorenz osteotomy had been performed nine months after accident. Roentgenogram showing union at site of fracture.

OPERATION

A vertical incision, four to five inches in length, is made over the outer aspect of the femur, starting above at the upper border of the greater trochanter and extending downward along the shaft of the bone. The muscular attachment is freed over the anterior aspect, so that the position of the head of the femur in the acetabulum can be easily defined. An oblique osteotomy (Figs. 1 and 2), extending from below upward and inward, is now made in the shaft of the femur at the level of the lower border of the femoral head, so that the upper border of the lower fragment can be placed *in situ* under the head and lower border of the acetabulum. After the shaft of the femur has been placed in this position, the wound is closed and the position is retained by means of a long plaster spica, for a period of from three to four months until union is complete.

Following the transference of the shaft of the femur to its new position, the upper fragment is drawn inward at its lower border by the muscular attachments which are common to both fragments. This

TABLE I

TWENTY-SEVEN CASES OF UNUNITED FRACTURE OF THE NECK OF THE FEMUR TREATED BY THE MODIFIED LORENZ BIFURCATION OPERATION

Case	Age (*Years*)	Occupation	Date of Fracture	Date of Operation	Preoperative Notes	End Result
A. W. T.	47	Commercial traveler	Jan. 1926	June 1926		Real shortening, 1¼ inches. Patient runs, dances, rides bicycle, walks miles. Motion in hip to within 30 degrees of full flexion. Patient well satisfied.
Mrs. S. S.		Shopkeeper	Dec. 1927	Jan. 1929	Real shortening, 1 inch.	Real shortening, 1¾ inches. Motion in hip to within 20 degrees of full flexion. Other movements normal. Patient working, as active as ever.
Miss A. L.	46	School teacher	Nov. 1927	March 1930	Real shortening, 1½ inches.	Real shortening, 1¾ inches. Motion in hip to within 20 degrees of full flexion. Good abduction. No rotation. Knee flexes to within 25 degrees of normal; aches after use. Patient is working.
E. L.	36	Laborer	Feb. 1929	June 1930		Real shortening, 1½ inches. Some abduction; 60 degrees of flexion. Knee flexes to 30 degrees. Patient walks some miles, but has not been able to resume his original occupation.
Mrs. S. S.	58		June 1929	July 1930	Real shortening, 1¾ inches.	Real shortening, 2 inches. Patient walking well and very well satisfied.
R. B.	45	Miner	June 1929	Sept. 1930	Real shortening, 1 inch.	Real shortening, 1½ inches. Motion in hip 25 degrees short of full flexion. Other movements normal. Patient walks miles, but cannot sit on heels, so is unable to return to work as miner.
Mrs. M. D.	52	Housewife	Sept. 1929	Sept. 1930	Real shortening, ¾ inch.	Real shortening, 1 inch. Hip flexes to well past a right angle, but gets tired at end of day. Other movements normal. Patient well satisfied.
Mrs. P.	63	Housewife	Jan. 1930	Oct. 1930	Real shortening, 1¼ inches.	Generalized rheumatism has developed. Patient can now stand more easily on the leg which has been operated upon than on the other leg.
J. H. J.	27	Actor	Jan. 1930	Jan. 1931	Real shortening, 1½ inches.	Patient did not return. Wrote that his condition was excellent and that he was working.

Mrs. A. W.	58	Housewife	May 1930	Nov. 1931	Real shortening, 1¼ inches.	Real shortening, 1½ inches. Hip shows 60 degrees of flexion, fair abduction, no rotation. Patient walks well and is working.
E. Q.	51	Mill hand	Feb. 1931	Sept. 1931		Flexion to 90 degrees in knee and hip. Pain in hip after use. Patient walks well.
J. B.	52	Miner	Feb. 1931	Jan. 1932	Real shortening, ¾ inch.	Real shortening, 1½ inches. Active flexion very limited; passive flexion of 20 degrees. Patient walks with a dip. Hip unstable and painless. X-ray shows bad result.
Mrs. Y.	56	Housewife	Jan. 1932	Sept. 1932		Real shortening, 1½ inches. Flexion to a right angle. No pain. Patient able to do washing and housework. Walks well and is very well pleased.
Mrs. N. R.	62		Apr. 1931	Oct. 1932	Real shortening, ½ inch.	Plaster removed in February 1933. Patient not seen again.
Mrs. E. J.	65	Housekeeper	Apr. 1931	Oct. 1932	Real shortening, 1½ inches.	Real shortening, 1½ inches. Patient walked fairly well, but fell downstairs a year after operation and twisted the knee and foot. Since that time, patient has not regained confidence in walking.
Mrs. B	53	Housekeeper	Sept. 1932	Jan. 1933		Flexion in knee of 15 degrees. Patient had oedema of both legs and thighs, which gradually diminished, but she could not be persuaded to discard the crutches or to walk out of doors.
T. P.	60	Unemployed	July 1932	July 1933	Real shortening, 1½ inches.	Real shortening, 2 inches. Free flexion of 45 degrees. No pain. Patient able to walk miles and is well pleased.
Mrs. N.	58	Waitress	March 1933	Dec. 1933	Real shortening, 1 inch. Only 20 degrees of flexion.	Real shortening, 1½ inches. Hip shows 30 degrees of free flexion, poor abduction, no rotation. Patient cannot climb stairs and is not working.

TABLE I (*Continued*)

Case	Age (*Years*)	Occupation	Date of Fracture	Date of Operation	Preoperative Notes	End Result
Mrs. P.	58	Nurse	Jan. 1933	Apr. 1934	Real shortening, 2 inches. Hip very painful.	Real shortening, 3 inches. Flexion to 80 degrees. Some abduction. Patient walks fairly well, but is not working. (Postencephalitic.)
Mrs. S.	57		Jan. 1934	May 1934	Real shortening, 1 inch.	Plaster removed in September 1934. Patient did not return.
Dr. S.	47	Physician	Jan. 1933	May 1934	Real shortening, 1½ inches.	Real shortening, 1½ inches. Good movements, no pain. Patient walking well and is working.
J. T.	54		Feb. 1933	June 1934	Real shortening, 1¾ inches.	October 1935, real shortening, 2 inches. No pain. Patient walks 2 miles easily. X-ray shows good result.
F. V.	47		Feb. 1918	July 1934	Real shortening, 2 inches.	Real shortening, 2 inches. Patient much improved, walks ¾ of a mile, becomes tired easily. X-ray shows good result.
Mrs. M.	55		May 1934	Sept. 1934	No shortening.	In March 1935, the patient was fitted with a canvas hip shield. Is making good effort at walking.
T. N.	58	Laborer	Sept. 1933	Oct. 1934	Real shortening, 1 inch. Patient had a fractured pelvis.	Real shortening, 2 inches. Flexion in hip to 35 degrees. Knee flexes to right angle. Patient has no pain, walks well with limp, is doing light work.
J. J.	28	Clerk	Dec. 1933	Oct. 1934	Real shortening, 1½ inches.	Real shortening, 2 inches. Hip shows flexion to a right angle, full abduction, fair rotation. Patient would like a little more flexion. He plays football and is unemployed.
Mrs. S.			Sept. 1933	Nov. 1934	Real shortening, ¾ inch.	Patient walks badly, is very neurotic and worried. X-ray shows excellent result.

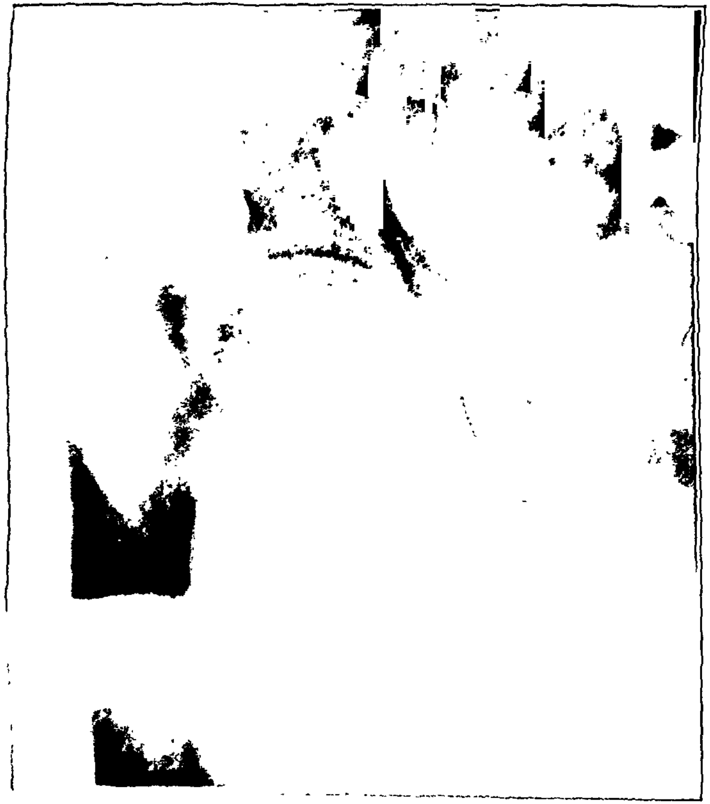

Fig. 6

J. B., aged forty-five years. Preoperative roentgenogram, fifteen months after accident.

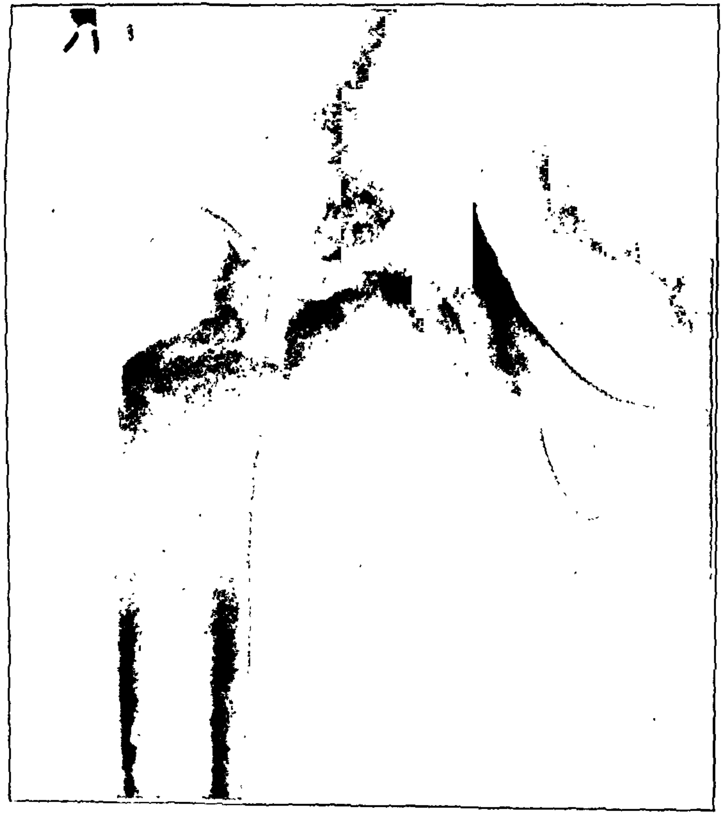

Fig. 7

J. B., aged forty-five years. Postoperative roentgenogram, showing that the site of the osteotomy was too high. The result was a failure.

FIG. 8

Mrs. Sh., aged fifty-seven years. Preoperative roentgenogram, one year after accident.

FIG. 9

Mrs. Sh. Postoperative roentgenogram. Osteotomy had been performed one year after the accident and the roentgenogram was

tilting inward of the upper fragment prevents the separation of the two raw divided surfaces and predisposes to union, which is essential for the production of a stable hip (Figs. 3 and 4). Occasionally, even in fractures which have remained ununited for a long period, union between the head and the greater trochanter occurs following this operation on account of the alteration of weight bearing (Fig. 5). In these circumstances, the stability of the joint is greatly increased and no permanent disability remains.

There are certain errors into which the surgeon may fall in the course of this very simple procedure. If the osteotomy is carried out at too high a level, the transference of the shaft of the femur under the head and acetabulum cannot take place, and the operation fails in its object (Figs. 6 and 7). Again, if the osteotomy is performed at too low a level, no weight is borne directly through the shaft of the femur, so that the strain at the site of non-union remains unaltered.

The object of making the osteotomy oblique is simply to make certain that union occurs between the divided fragments. If a transverse osteotomy is done, the result is excellent, but there is a grave risk of separation of the two portions of the femoral shaft, resulting in non-union.

If the osteotomy is performed at a very acute angle, the upper end of the shaft of the femur is so pointed that fracture of this margin may occur, as happened in one of the author's cases.

The essentials for success in this type of treatment are:

1. Correct position of the transferred shaft of the femur under the acetabulum and femoral head. (See Figures 8 and 9.)

2. Union between the divided fragments of the shaft of the femur, without which the hip joint remains flail and painful.

3. A position of very slight abduction, in order to prevent the development of a subsequent knock-knee deformity.

The advantages of this form of treatment are:

1. Its simplicity and the absence of shock which is of great importance in elderly patients.

2. The comparative certainty of relief in contrast with many of the other procedures whose advantages are problematical.

3. The fact that the operation may be performed in spite of a very long interval of non-union.

4. No necessity for any form of walking splint following the removal of plaster.

HEMATOGENOUS ACUTE OSTEOMYELITIS IN CHILDREN*

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One hundred and ten patients suffering from hematogenous acute osteomyelitis, exclusive of the bones of the head and the face, were admitted to the Orthopaedic Department of the Children's Hospital during the six-year period from June 1928 to June 1934.

An effort has been made to determine the effect upon the patients of early and late operations with regard to the mortality and development of secondary foci.

CLASSIFICATION

The character of the pathological changes of the bones, as determined by roentgenographic studies, places these patients in four groups:

1. Multiple diffuse type—thirty-four cases;
2. Single diffuse type—sixty-four cases;
3. Circumscribed type (Brodie's abscess)—eight cases;
4. Sclerosing osteomyelitis—four cases.

FATAL CASES

Exclusive of the two groups of circumscribed (Brodie's abscess) and

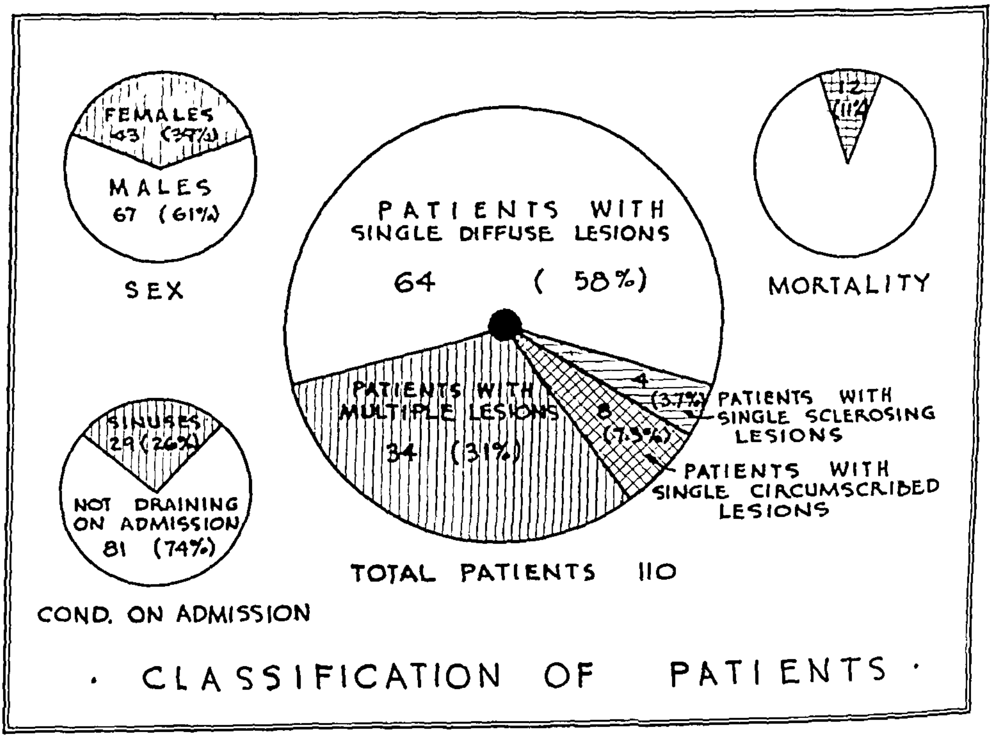

FIG. 1

* Read in part before the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

sclerosing bone infections, in which there were no fatalities, there were ninety-eight instances of single and multiple diffuse bone infection. Twelve, or 12.2 per cent., of these ninety-eight patients died.

A discussion of the patients who died must be directed chiefly toward a retrospective study of the propriety of operative interference. These patients were attacked surgically at varying periods in the course of the disease: six within the first week; three during the second week; and three between the sixteenth and twenty-third day following the onset of the infection.

Surgical Treatment

Operations entailing resection of bone to obtain drainage were done in seven patients. In the remaining five patients, soft-tissue abscesses developed, which were drained without an attempt to expose or to explore the underlying bony structures.

The precarious condition of the patients in both of these groups was manifested by the development of the following serious complications:

1. Bronchopneumonia—three cases;
2. Bacterial endocarditis—two cases;
3. Brain abscess—one case;
4. Meningitis—one case;
5. Lateral sinus thrombosis—one case.

Interval between Operation and Death

Six patients (50 per cent.) died within the first week, and five of these within the first twenty-four hours after operation. One death should be considered a surgical accident, as the autopsy revealed a large pulmonary embolus. Two patients died during the second week, three within the next eight days, and one survived for 220 days. Such a high mortality within a short postoperative period must cause grave reflection as to the most appropriate time for operation. We are of the opinion that this investigation and other studies indicate that operative interference may well be and often is undertaken too early rather than too late in the course of the disease.

TREATMENT

The recent text-books on surgery impress the reader with the fact that a focus of hematogenous acute osteomyelitis must have immediate drainage. In fact, one should arise in the middle of the night to drain these areas because of the danger of rapid dissemination of infection and its products, thought to be under mechanical pressure. To wait for roentgenographic evidence of localization is classed as gross neglect.

Ninety-eight patients, with single or multiple diffuse lesions, none of which were Brodie's abscesses or infections of the sclerosing type, may be discussed with regard to the time of surgical drainage. Four patients were classified as undetermined because the histories were incomplete

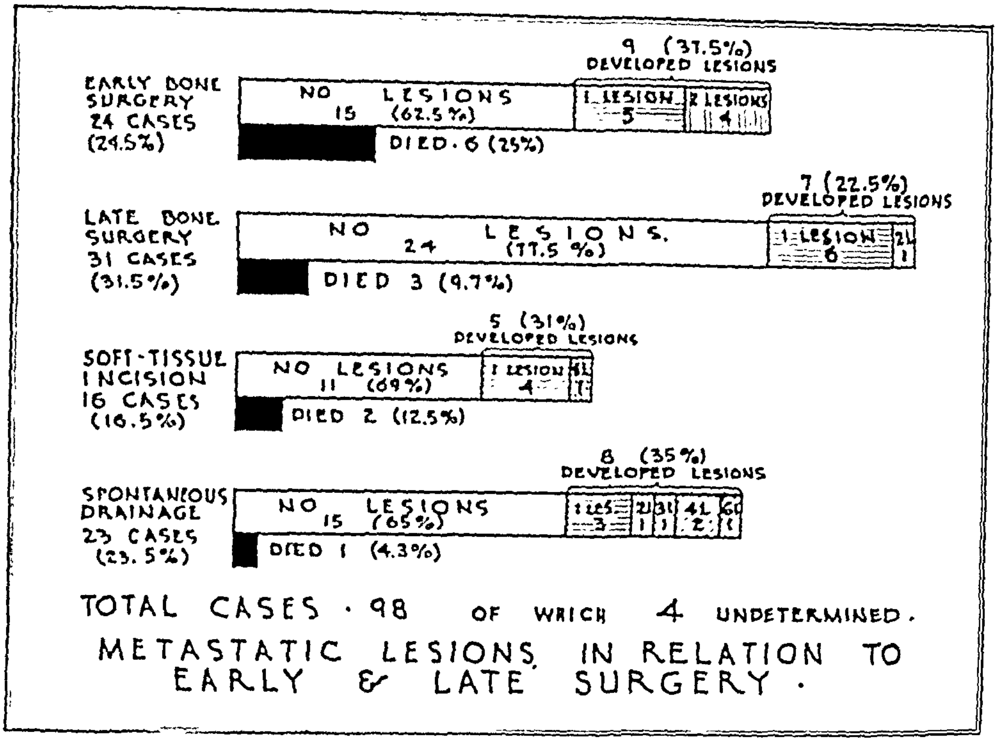

FIG. 2

and these individuals could not be located for an examination to determine accurately the end results. The remaining ninety-four patients may be grouped in four divisions, according to the type of treatment.

Group I—Early Surgical Drainage

This group comprised twenty-four patients in whom drainage of the medullary canal at the site of the bone infection was done within the first seven days of the disease. In these patients drainage was done before roentgenographic evidence of osteomyelitis was present, and in many of them the recovery of bacteria furnished the only evidence of infection.

Group II—Delayed Surgical Drainage

This group included thirty-one patients in whom the medullary cavity was drained during the period from the seventh to the twenty-eighth day of illness. A majority of these patients showed roentgenographic evidence of disease. Pus was found in all and in many there was a subperiosteal or soft-tissue abscess. At this point we wish to state that in our opinion a comparison between Groups I and II is justified because, by and large, the patients comprising Group II (which is the larger group) were in general as acutely and desperately ill as the patients in Group I and, according to the old dictum, "demanded" operation as definitely as those in Group I.

Group III—Incision of Soft Tissues

In this group were sixteen patients in whom only a soft-tissue in-

cision was made. This type of operation was for the most part performed by the practitioner in the home, and these patients entered the hospital with one or more draining sinuses and roentgenographic evidence of osteomyelitis.

Group IV—Spontaneous Drainage

This group of twenty-three patients included those who had had neither surgical drainage of the bone nor incision of the soft tissues. The abscesses perforated the skin spontaneously. On admission to the hospital, each of the patients had one or more draining sinuses and roentgenographic evidence of osteomyelitis.

FINDINGS

Mortality

A comparison of the mortality rates reveals that it was highest in Group I. Six, or 25 per cent., of these twenty-four patients who had early adequate drainage of the medullary canal within seven days of the onset of illness, died. There were no macroscopic changes suggestive of osteomyelitis, and in many cases there was only bacteriological or microscopic evidence of infection. Three of these deaths (50 per cent.) occurred within forty-eight hours after the operation, which was not unduly prolonged, radical, or complicated by hemorrhage.

The medullary canal was drained between the seventh and twenty-eighth days of illness in the thirty-one patients of Group II. Three of these thirty-one patients, or 9.7 per cent., died. These patients had intramedullary subperiosteal or soft-tissue abscesses. A large percentage also had some roentgenographic evidence of bone infection.

The mortality rate dropped 15 per cent. when medullary drainage was carried out after the first week of the illness.

The lowest mortality was in Group IV, the patients in whom the abscesses drained spontaneously. Only one of these twenty-three patients, or 4.3 per cent., died and this death resulted from a complication, a staphylococcus meningitis which developed four months after a sequestrectomy. This group does not offer an adequate comparison because the acute phase of the illness took place before admission to the hospital and no records or accurate observations of the virulence of the infection are available. We have been unable to escape the impression, however, that the "dilatory, inefficient" treatment in many instances probably saved the lives of some of these patients, which is after all a matter of some importance. Groups I and II are comparable because the acute phases of the illness were observed and recorded.

Metastatic Lesions

In Group I, nine of the twenty-four patients (37.5 per cent.) developed metastatic lesions. Two of these nine patients had a metastatic lesion within forty-eight hours after surgical drainage. Subperiosteal ab[illegible]

were not present at operation. The maximum number of metastatic lesions was two. This number of lesions was found in four patients in this group.

In Group II, where the medullary canal was drained after seven days, metastatic lesions developed in seven of the thirty-one patients (22.5 per cent.). The maximum number of two lesions occurred in only one patient.

Group III was made up of sixteen patients who had only drainage of abscesses which had ruptured in the soft tissues. Of these, five (31 per cent.) developed metastatic lesions. In four there was one secondary focus of infection, and in one there were five secondary foci of infection.

In Group IV, where no surgery was done but spontaneous drainage took place, eight of the twenty-three patients (35 per cent.) developed metastatic lesions, and in this group the incidence of multiple metastatic infections was materially increased. One patient developed two metastatic abscesses; one had three; two developed four; and one had six.

CONCLUSIONS

These findings suggest that perhaps the answer to the problem is not the earliest possible surgical invasion of the bone, but a well-timed adequate drainage of the medullary canal when the individual's resistance is at the highest possible point.

It has been our repeated experience that an acutely suffering child, who enters the wards in a badly dehydrated condition with a very high temperature and pulse rate, will become a vastly better operative risk in twenty-four, forty-eight, or even seventy-two hours, during which the suffering has been relieved and the dehydration overcome. The improvement in the general condition will be obvious and the chart will confirm this impression. The lesion will probably be quite evident when the child enters the hospital, as will the eventual necessity for an operative procedure, but timing is the important factor in treating acutely sick children. A blood-borne infection of bone may be more successfully handled by adhering to the principle of allowing the infection to localize. A catastrophe may result from a too early ostectomy of an infected bone, for the same reason that incision of a brawny cellulitis is often fatal.

On the other hand, it seems unwise negligently to permit an individual to harbor a well-formed abscess for days, or to drain such an abscess only partially and imperfectly. Such procedures are favorable to the formation of multiple metastatic lesions, as is evidenced by the preponderance of these lesions in cases where only incision of the soft tissues was carried out, or those in which spontaneous rupture of the abscesses was permitted.

THE HEALING OF SEMILUNAR CARTILAGES *

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The semilunar cartilages have a very limited blood supply. By arterial injection with an opaque medium † one can discern a network of fine vessels from the capsule, entering the convex border of the meniscus but disappearing almost immediately. Because of this, one might expect healing in peripheral meniscus detachments, but none in tears limited to the semilunar cartilage itself. This paper is a report of our experiments on the healing of peripheral detachments,—longitudinal and transverse incisions in the internal semilunar cartilages of the knees of dogs.

In each case, the knee joint was opened by a curved incision, the internal lateral ligament being cut in some instances. No postoperative fixation was used and, with one exception (Dog 11), all the dogs ran about in a perfectly normal way within a few days after the operation.

DOG 1

The anterior half of the internal semilunar cartilages of both knees was freed peripherally from its capsular attachment (Fig. 1). One hundred days later, the animal was sacrificed and the knee joints were opened. There was not the slightest evidence of meniscus displacement or, in fact, of any pathology. The semilunar cartilages were perfectly healed to the capsule.

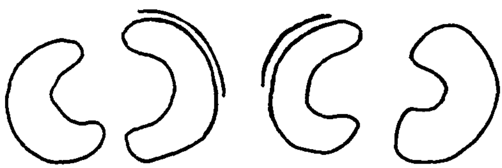


FIG. 1

Dog 1. Drawings illustrating incisions.

DOG 2

Left knee: The anterior half of the internal semilunar cartilage was incised longitudinally, the incision beginning laterally at the capsular attachment (Fig. 2-A).

Right knee: In addition to the longitudinal incision (Fig. 2-A), the posterior half of the cartilage was freed from its capsular attachment.

Sixty days later the joints were opened and the findings (Fig. 2-B) were as follows:

Left knee: The posterior half of the meniscus was normal. The external fragment of the anterior half was completely covered with connective-tissue pannus growing in from the capsule. This pannus had attached itself to the medial fragment and held it snugly in place so that there was no danger of displacement.

Right knee: Here again the two halves of the anterior portion had been glued together by connective-tissue pannus, from

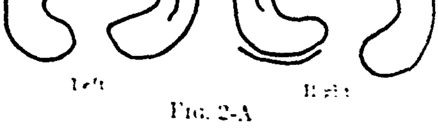
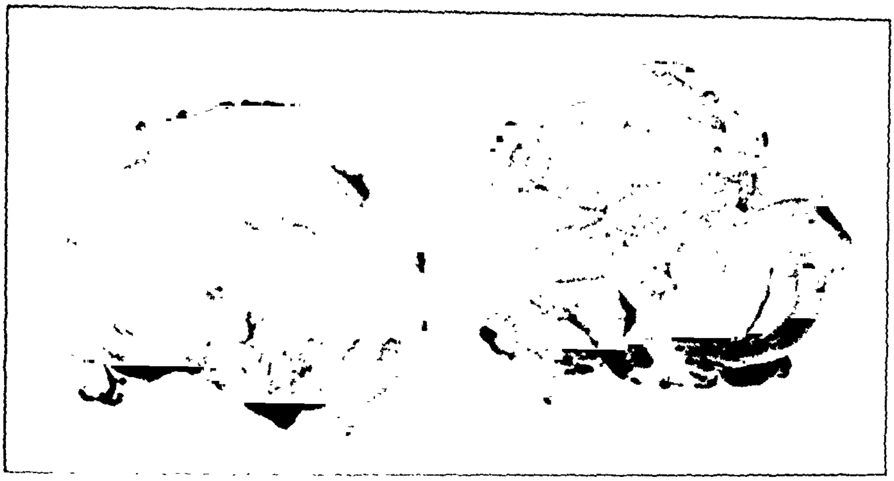


FIG. 2-A

Dog 2. Drawings illustrating incisions.

* Received for publication September 5, 1935. The material in this paper was presented at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 13, 1936.

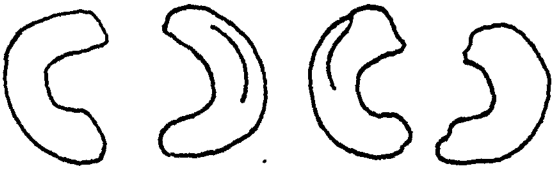
† Poth's modification of Hill's radiopaque mass is very satisfactory for this purpose.



Left Right

FIG. 2-B

Dog 2. Note granular degeneration of the internal articular cartilages. *The anterior longitudinal incisions healed by pannus formation from the* synovial membrane laterally. Broad bands of scar tissue are seen holding the posterior horn of the right meniscus to the synovial membrane.



Left Right

FIG. 3

Dog 3. Drawings showing incisions.

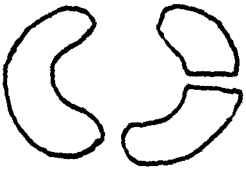
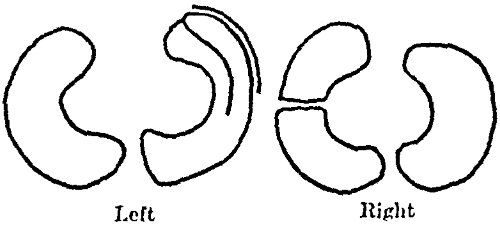


FIG. 4

Dog 4. Drawing showing transverse division of the internal meniscus of the left knee.



Left Right

FIG. 5-A

Dog 5. Drawings illustrating incisions.

Left Right

FIG. 5-B

FIG. 5-B

Dog 5. Forty-two days after operation. The longitudinal incision has healed anteriorly but not posteriorly. The transverse incision is filled in with connective tissue.

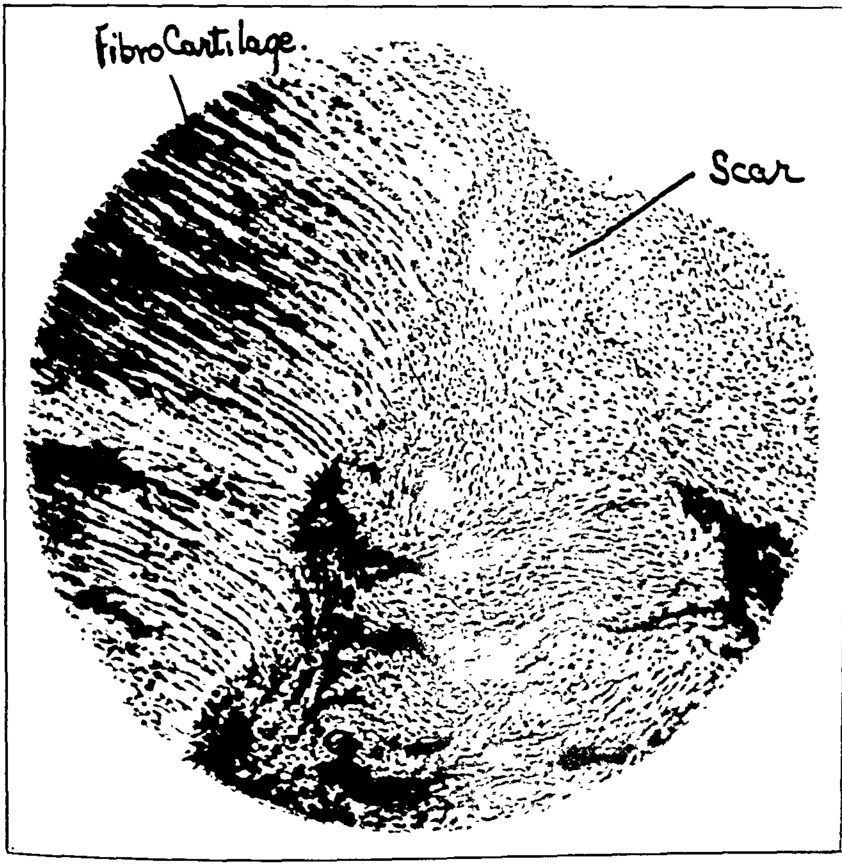


FIG. 5-C

Photomicrograph of coronal section through incision of right knee, showing junction of meniscus stump with the scar tissue. This tissue arises laterally from the synovial membrane and contains no cartilage.

the synovial membrane, which had grown across the external half into and filling the incision. The posterior half of the meniscus was narrowed and yellowish, and was connected with the synovial membrane posteriorly by broad bands of scar tissue.

There was also an early granular degeneration of the internal tibial articular cartilages.

Dog 3

Left knee: A short longitudinal incision was made in the anterior half of the external portion of the internal meniscus (Fig. 3).

Right knee: A short longitudinal incision was made, as in the left knee, but communicating with the capsule laterally (Fig. 3).

Sixty days later, the incision in the left meniscus was unhealed, while that in the right, which communicated with the capsule, had healed perfectly.

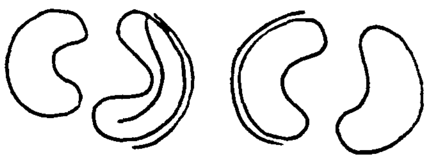


FIG. 6-A

Dog 8. Drawings illustrating menisci

FIG. 6-B

Dog 8. Transverse section of internal semilunar cartilage, showing unhealed incision. The edges of the incision are covered with fibrin.

FIG. 6-C

Dog 8. Transverse section through the incision taken posteriorly where it does not completely penetrate the meniscus. There is no evidence of healing. Edges of incision are covered with fibrin.

FIG. 7-A

Dog 9. Left knee, showing perfect apposition of the fragments of the internal semilunar cartilage.

FIG. 7-B

Dog 9. Left knee, twenty-three days after operation. The fragments are separated, and there is no evidence of healing.

DOG 4

The internal meniscus of the left knee was divided transversely (Fig. 4). Two weeks later the two fragments were joined by young connective tissue arising from the synovial membrane and capsule laterally.

DOG 5

Left knee: The anterior half of the internal meniscus was freed from its capsular attachment and split longitudinally (Fig. 5-A), the anterior end of the incision being external at the old capsular attachment.

Right knee: The internal meniscus was divided transversely (Fig. 5-A), just anterior to the internal lateral ligament.

Forty-two days later, the following conditions were noted:

Left knee: The meniscus was reattached to the capsule. The anterior end of the longitudinal incision was filled with connective tissue which welded the two fragments together. The posterior end of the incision was unhealed. (See Figure 5-B.)

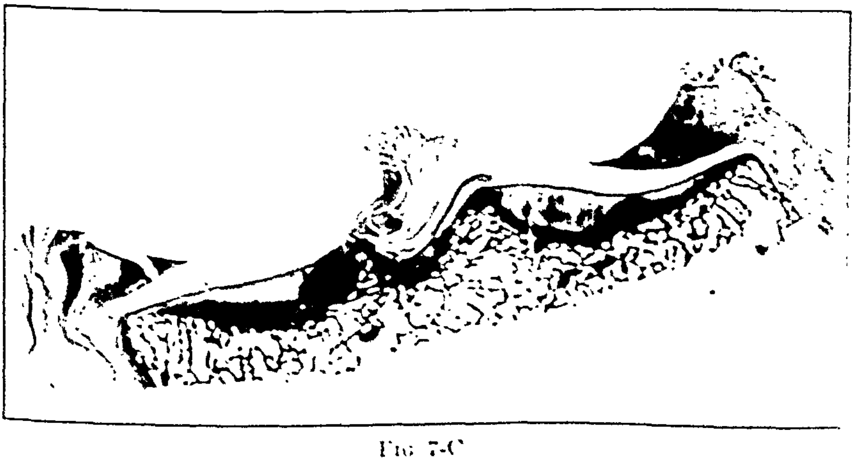


FIG. 7-C

Dog 9. Frontal section through joint of right knee, [illegible] meniscus twenty-three days after longitudinal [illegible] meniscus. In the center, the stump of the [illegible]

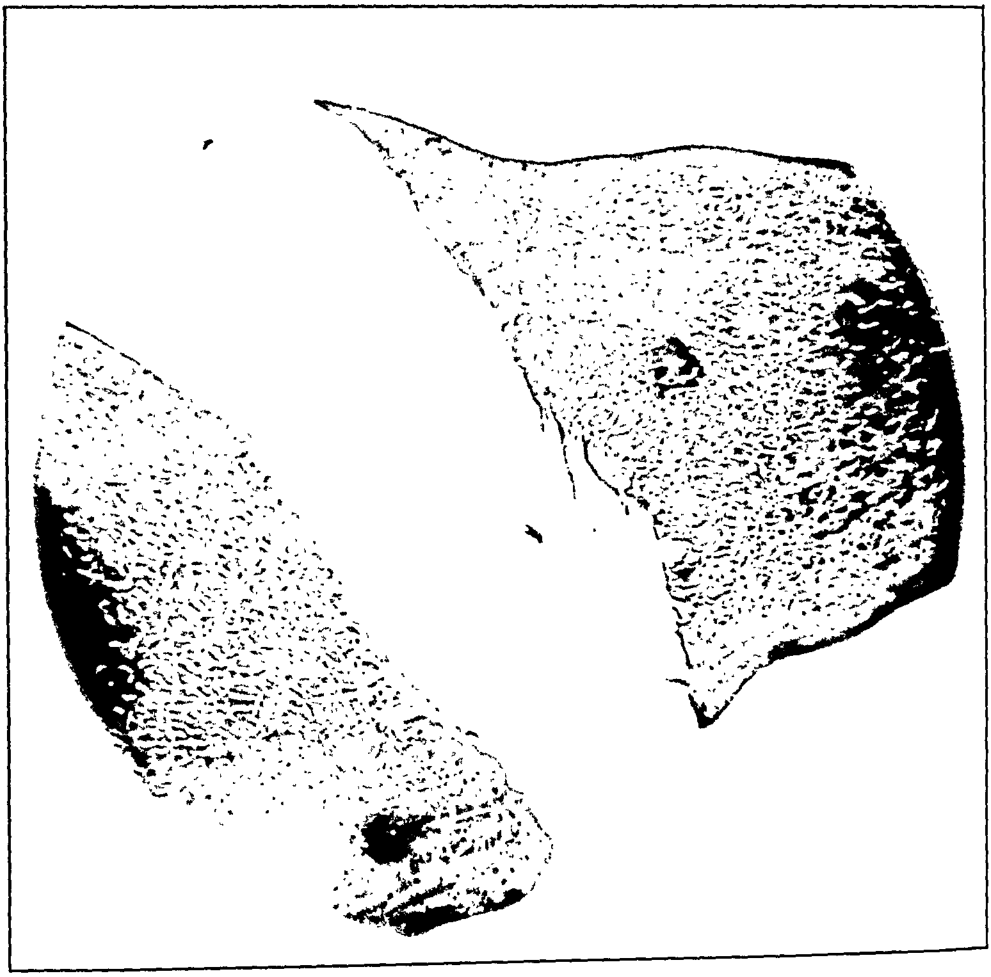


FIG. 7-D

Dog 9. Photomicrograph of incision through the internal semilunar cartilage of the right knee twenty-three days after operation. There is no evidence of healing or of necrosis of the internal fragment.

Right knee: The two halves of the cartilage were separated by about two millimeters. This space was occupied in its peripheral two-thirds by a yellowish granulation tissue which held the two halves firmly together. (See Figures 5-B and 5-C.)

DOG 6

The medial two-thirds of the internal menisci were freed from the capsule peripherally. Forty days later, perfect healing had occurred.

DOG 7

Both internal menisci were divided transversely. Twenty-one days later, the cut surfaces were found to be separated by about two millimeters, the space being filled with scar tissue growing in from the synovial membrane at the periphery.

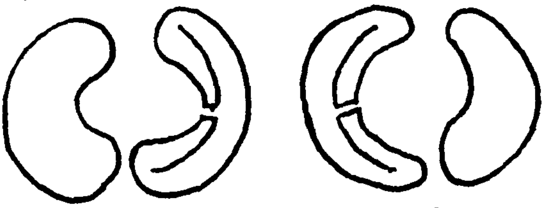


FIG. 8

Dog 10. Longitudinal incision plus transverse incision in mesial fragment.

DOG 8

Left knee: The internal meniscus was incised longitudinally through the greater part of its length. It was also freed peripherally, with the exception of the attachments of the anterior and posterior horns. (See Figure 6-A.)

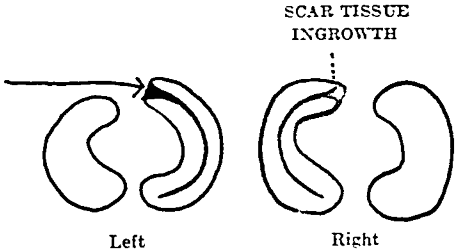


FIG. 9

Dog 11. Thirty days after operation.

Right knee: The capsular attachment was severed, except for that of the tips of the anterior and posterior horns (Fig. 6-A).

Fourteen days later the dog was sacrificed and the following observations were made:

Left knee: The joint contained considerable turbid fluid with large bits of fibrin. The synovial membrane was deeply congested. (Smears from the fluid showed a moderate number of pus cells; the cultures were negative.) Anteriorly, the longitudinal incision was glued together by pannus which had grown inward from the synovial membrane over the peripheral fragment. Posteriorly, the incision was glued together with fibrin, but no true healing had occurred (Fig. 6-C).

Right knee: There was a small amount of clear fluid in the joint, with slight congestion of the synovial membrane. The meniscus was very well healed in its normal anatomical position.

DOG 9

A longitudinal incision was made through the greater part of the internal semilunar cartilage of each knee, care being taken to keep the incision in the middle third.

Twenty-three days later the knee joints were opened. The two fragments of the cartilages were lying next to each other in perfect apposition (Fig. 7-A), but could be separated with ease, there being no evidence of healing (Figs. 7-B, 7-C, and 7-D).

DOG 10

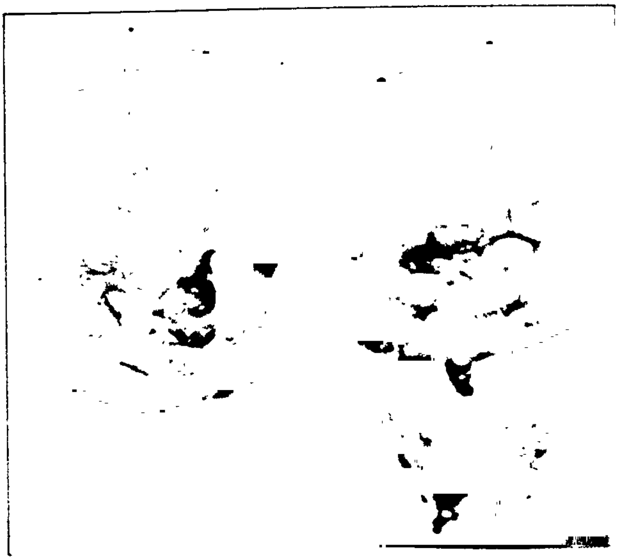
The internal semilunar cartilages were incised longitudinally and the internal fragment was divided transversely as shown in Figure 8.

Twenty-six days later, the fragments were found to be perfectly apposed. There was not the slightest evidence of healing, however.

DOG 11

The internal cartilages were split longitudinally, the anterior ends of the internal fragments being completely separated from the transverse ligaments.

Thirty days later, the two fragments were in perfect apposition. At the anterior ends they



Left Right

FIG. 10

Dog 12. Forty-two days after operation. Note the marked pannus formation, [illegible] and thickening, [illegible] articular-cartilage degeneration. The anterior [illegible] the internal [illegible] in pannus.

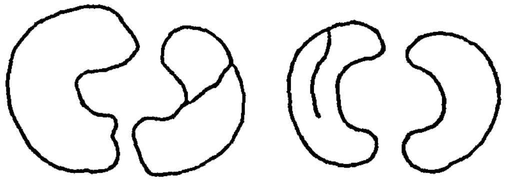


FIG. 11-A

Dog 13. Drawings illustrating incisions.

were firmly united by a connective-tissue ingrowth from the synovial membrane (Fig. 9).

DOG 12

The internal cartilages were incised longitudinally, as in the case of Dog 11. For three weeks following the operation, the animal refused to stand. Both knees were somewhat swollen, but not locked. After he had begun to stand, he walked with great difficulty, bearing practically no weight on the right hind leg. Forty-two days after operation, at the time of sacrifice, the animal was walking around, but still limped badly.

Both knees contained a moderate amount of clear fluid. The synovial membrane was thickened, and a great deal of pannus covered the cruciate ligaments and the peripheral margins of the semilunar cartilages, the internal menisci being lusterless and yellow. Anteriorly, where incised, the two fragments were incorporated in a syncytium of connective tissue streaming in from the synovial membrane. The medial articular cartilages of the tibia had degenerated, and, on the right side, there was an area of degeneration on the anterolateral aspect of the lateral femoral condyle. It is impossible to explain this advanced degree of degeneration. (See Figure 10.)

DOG 13

Left knee: The internal semilunar cartilage was divided obliquely across at the level of the internal ligament (*Fig.* 11-A).

Right knee: The cartilage was split longitudinally, the incision beginning anterolaterally at the synovial membrane (*Fig.* 11-A).

Fifteen days later, the joints were opened and the findings were as follows:

Left knee: The two halves of the cartilage were separated by about two millimeters. This space was well filled with connective tissue originating from, and directly continuous with, the synovial membrane laterally (Fig. 11-B).

FIG. 11-B

Dog 13. Left knee, fifteen days after operation, showing scar tissue welding the two stumps together.

Right knee: The synovial membrane had given origin to a connective-tissue ingrowth into the anterior end of the incision for a distance of about two millimeters. The major portion of the incision showed no evidence of healing.

DOG 14

Longitudinal incisions were made in the internal cartilage of each knee, communicating with the synovial membrane anterolaterally (Fig. 12-A). Postoperative recovery was uneventful in every way and, at the time of sacrifice (fifteen days later), the animal appeared normal. There was no evidence of locking at any time.

Left knee: The internal fragment was displaced medially and twisted upon itself. Anteriorly, a heavy growth of deeply congested pannus held the two fragments together (Fig. 12-B).

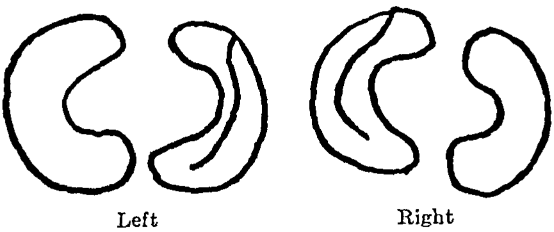


FIG. 12-A

Dog 14. Drawings illustrating incisions.

Right knee: The internal fragment was displaced farther into the joint, but had not undergone volvulus. Otherwise, the condition was the same as that of the left.

Left Right

FIG. 12-B

Dog 14. Fifteen days after operation. Note displacement of internal fragments. The heavy growth of pannus appears black in the photograph.

SUMMARY AND CONCLUSIONS

In seven knee joints of dogs, the internal semilunar cartilages were freed, to a varying extent, from their attachments to the synovial membrane and capsule peripherally. Within a few days, the dogs walked and ran about in a normal way; no locking of the joints was produced. After a period of time (two weeks to three and a half months), the animals were sacrificed and the joints were examined. In each case, the cartilage was firmly healed in normal anatomical position.

In thirteen joints, the semilunar cartilages were incised longitudinally. In each case the incision did not communicate with the synovial membrane and varied in its position in the cartilage. With one exception (Dog 1[illegible]), the two fragments of the semilunar cartilages remained closely apposed although no postoperative fixation was used. In spite of this close apposition, there was not the slightest evidence of healing between the fragments during the period of observation (three weeks to two months).

In seven joints, the longitudinal incision was carried through the convex edge of the meniscus to the synovial membrane. In each case, the peripheral end of the incision healed by connective tissue arising from the

synovial membrane and capsule. In one instance (Dog 3), the entire incision was filled with scar tissue.

When the semilunar cartilage was divided transversely (in six joints), the two fragments were separated a short distance. The free space thus produced was obliterated by an ingrowth of connective tissue from the synovial membrane, linking the two fragments firmly together. This connective tissue, which grossly resembled fibrocartilage, contained no cartilage cells.

Our experiments indicate that:

1. Tears which are limited to the semilunar cartilage probably never heal.

2. A torn meniscus can be healed by connective tissue if the tear communicates with the synovial membrane laterally.

3. A complete transverse or oblique tear results in some separation of the fragments, but the intervening space fills in with connective tissue arising from the synovial membrane. This connective tissue is quite firm in three weeks, which suggests the length of time necessary for complete fixation in these cases.

4. If the meniscus is partially torn from its peripheral attachment, it heals in normal anatomical position without difficulty.

1. Poth, E. J.: A Modification of Hill's Radiopaque Mass for the Injection of Lumina. J. Lab. and Clin. Med., XIX, 1241, 1934.

PYOGENIC OSTEOMYELITIS OF THE SPINE

An Analysis and Discussion of 102 Cases

BY JACOB KULOWSKI, M.D., F.A.C.S., ST. JOSEPH, MISSOURI

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INTRODUCTION

Although pyogenic osteomyelitis of the spine is generally considered to be relatively uncommon, numerous case reports and descriptions of the disease have been published. More recently, benign forms have been recognized, due to extended experience and more discriminating diagnoses. These forms, almost without exception, have been considered as tuberculous in the past, in spite of the well-known greater incidence of pyogenic bone and joint lesions in general. It is significant that the ratio of tuberculous spondylitis to pyogenic osteomyelitis has been but two to one, during the past three years in the Orthopaedic Clinic at Iowa City, since interest in pyogenic lesions has been aroused.† *All septic patients should be watched for spinal complications and, if such patients die, the entire spine should be examined at autopsy.*

Pyogenic osteomyelitis of the spine differs from other more common localizations of the disease chiefly because of its relatively vulnerable anatomical situation. Therefore, the primary lesion is often overlooked or subordinated to the more extensive secondary purulent infiltrations in the adjacent vital organs and body cavities, which are characteristic of the disease.

This series includes sixty instances of pyogenic spondylitis observed up to September 1934 at the University Hospitals, Iowa City—3.94 per cent. of the total series of 1,500 cases of pyogenic osteomyelitis—and forty-two cases obtained by questionnaire. The total number of cases reported in the literature, including the present group, is well over 300.

INCIDENCE (TABLE I)

In the questionnaire series, males predominated in the usual ratio of about two to one. It is of particular interest to note that this was considerably higher in the Iowa series. Pyogenic spondylitis is not primarily a disease of the growing period. The majority of these cases occurred after the third decade, when the spine is completely formed. Instances of the disease have been reported in very young children, but not in infants. The striking incidence of pyogenic spondylitis in adults, in contrast to the predilection of osteomyelitis in its long bone manifesta-

* Services of Arthur Steindler, M.D., and H. L. Beye, M.D.
† Personal communication from Ernst Freund, M.D.

TABLE I

AGE AND SEX INCIDENCE OF PATIENTS WITH PYOGENIC SPONDYLITIS

Incidence	Iowa Series	Questionnaire Series	Total
Sex:			
Males	46	28	74
Females	14	14	28
Age:			
Youngest	8 years	12 years	10 years
Oldest	62 years	58 years	60 years
Average	31 years	31 years	31 years
Decade:			
First	1	0	1
Second	19	13	32
Third	8	7	15
Fourth	12	9	21
Fifth	11	3	14
Sixth	5	6	11
Seventh	4	0	4
Total	60	38 *	98

* In four cases in this series, the ages were unknown.

tions for children, may be in part accounted for by the lack of true epiphyseal growth of the vertebrae, persistence of rich cellular bone marrow, and sluggish voluminous blood supply. The latter condition aids the early transport of organisms and thrombo-embolic processes in the vertebral bone marrow in bacteriemic conditions and acute infectious diseases.

PATHOGENESIS (TABLES II AND III)

The apparent port of infectious entry was noted in approximately 40 per cent. of the Iowa series, in which topical infections predominated. The efficient treatment and eradication of infection constitutes an important prophylactic measure. Organisms were found in the vertebral marrow by Fränkel even after the primary focus had healed. This observation elucidates the intervals which were noted in many cases between the port of entry and the clinical manifestations of the disease. In some cases, the relation of a focal infection to the spinal disease is obvious or it may be incidental. In many instances, this could be demonstrated. The relationship between intrathoracic infectious diseases and dorsal spondylitis is obscure in some cases. Such foci may occur simultaneously or become directly involved by extension from one or the other lesion. Careful clinical, bacteriological, and pathological studies are often necessary to establish the facts in the individual case.

Spinal lesions may be classified as direct and hematogenous. Direct

TABLE II

APPARENT PATHOGENESIS [illegible]IOWA SERIES ONLY)

Type of Infection	No. of Cases	Total
Topical infection *	12	
Pneumonia	5	
Mastoiditis	2	
Prostatic abcess	1	
Puerperal sepsis	1	
Thrombophlebitis	1	
Sore throat	1	
	—	23

* The topical infections were as foll[illegible] felon, 2; cellulitis (face), 1; carbuncle, 2; sties, 1. There was a history [illegible] eight cases.

infections occur postoperatively, th[illegible] infected decubiti or by extension from a neighboring suppurati[illegible] The hematogenous forms may arise as initial spinal foci or a[illegible]atic lesions after one or more bony localizations of the disease ha[illegible]dy been established. In this (Iowa) series of fifty-three cases, fo[illegible]ons were initially spinal and thirteen were metastatic.

The spine was directly and serio[illegible]red in eight cases. Trauma is recorded in about 30 per cent. of a[illegible] of pyogenic osteomyelitis and its significance must be recogniz[illegible] The spine, perhaps more than any other structure, is exposed to functional stresses and strains and is particularly subject to degenerative changes which enhance infectious invasions under favorable conditions.

The staphylococcus is the invading organism in the great majority of cases. Secondary local and general invasion is not uncommon. Because of the serious nature of the pathological anatomy, the less severe forms of pathogenic and even non-pathogenic organisms may gain a good foothold and cause extensive destruction. The blood cultures are often positive during the bacteriemic phases of the disease.

TABLE III

PATHOGENETIC CLASSIFICATION

	Iowa Series	Questionnaire Series	Total
Spinal Lesion:			
Direct	7	2	9
Hematogenous	53	40	93
Infectious Agent:			
Staphylococcus	29	26	55
Streptococcus	6	4	10
Mixed	5	3	8
Positive blood culture	6	7	13

TABLE IV

PATHOLOGICAL ANATOMY

Series	Involvement of Vertebra	Cervical Region	Dorsal Region	Lumbar Region	Sacrum	Coccyx	Total
Questionnaire * . .	Body	1	6	17	5	2	31
	Posterior process	2	1	3	1		7
	Combined			4			4
Iowa **	Body	4	22	23	3	1	53
	Posterior process		2	4			6
	Combined	1					1
Total		8	31	51	9	3	102

* In the questionnaire series, the posterior foci were as follows: transverse processes, five; spinous process, one; and the lamina, one. More than one segment was involved in only eleven instances (26 per cent.).

** In the Iowa series, the localization was dorsolumbar in four instances and lumbosacral in ten. In the dorsal region, the posterior localizations were in the laminae; in the lumbar region, the foci involved the transverse processes in two cases, the lamina in one case, and the spinous process in one. The great majority of the foci in the vertebral bodies involved two or more segments.

SEGMENTAL DISTRIBUTION AND PATHOLOGICAL ANATOMY (TABLE IV)

Contrary to earlier belief, pyogenic spondylitis is essentially a disease of the vertebral bodies and their contiguous discs, and seems to have a predilection for the lumbar region, although the dorsal portion is almost as well represented in the Iowa series. In the earlier literature, about 40 per cent. of the cases occurred in the posterior portions of the vertebrae. The predilection for the bodies, as noted at present, may be accounted for by the fact that the surgeon is now better able to discriminate between pyogenic spondylitis and tuberculosis, and because the heaviest and largest vertebrae are in the lumbar region. The transverse and spinous processes are more or less rudimentary structures which form lever arms for muscular and ligamentous attachments.

Pyogenic spondylitis is almost always a diffuse lesion. In this series, practically every instance of the disease involved the bodies or the bodies and posterior processes combined. More than one spinal segment is affected as a rule, at least in the later stages of the disease. This is conditional upon the anatomical and architectural continuity of the cancellous structure in the body and posterior portion of the vertebra. This structural continuity is reflected in the horizontal and vertical trabecular systems. The lesions are of irregular size and shape and their limitation is determined by the vascular collateral circulation. Extension to contiguous disc and vertebral body is further aided by the absence of the

FIG. 1

Autopsy specimen showing pyogenic osteomyelitis of the lower lumbar and lumbosacral spine, with late involvement of the sacro-iliac joints. There is complete bony fusion at the lumbosacral junction, and general eburnation. The intervertebral disc between the fourth and fifth lumbar vertebrae is narrowed, while the discs between the second and third and third and fourth lumbar vertebrae show a definite tendency to herniation.

W. M., aged twenty-three years, was admitted in March 1931. Roentgenographic examination revealed a diffuse increased condensation of the entire lumbosacral region and destructive lesions of the sacro-iliac joints. The patient died in September 1932, following a prolonged stormy illness. The pathological diagnosis was: (1) chronic suppurative arthritis of both sacro-iliac joints; (2) pyogenic osteomyelitis of the lumbosacral spine; (3) right psoas abscess; (4) suppurative phlebitis of the left femoral vein; (5) multiple metastatic soft-tissue abscesses; (6) chronic osteomyelitis of the scapula (healed); (7) amyloidosis of liver and spleen; (8) septicaemia. Histologically, the picture was characterized by numerous focal areas of necrosis, active inflammation, and healed foci.

circumferential cartilage plate and the lack of a definite protective subchondral layer of compact bone as seen in normal joints. The nature of the spongy bone and the peculiarities of the blood supply tend to develop a carious form of destructive necrosis. However, small sequestra, composed of the thin outer compact layer and that portion of the body formed by the ossification of the secondary epiphysis, may and do occur. Condensation, proliferation, and bone production are encouraged by the natural sluggishness of the vascular current. Characteristically, direct infections cause an ulcerative surface lesion of the body, whose depth depends upon the nature of the infectious agent and its duration. The type of lesion in the hematogenous forms is variable and may be destructive and ulcerative, solitary, and localized, primarily in the disc alone, in the disc and the contiguous bony structures, or even in the subperiosteal area. The primary focus is practically always in the bone marrow (usually that of the vertebral bodies) or in the disc. Extension of the lesion may occur also by erosion anteriorly under the longitudinal ligament. Occasionally, multiple small foci of different durations are noted throughout the bodies with reactive zones of eburnation surrounding them. Distinct remnants of the cartilage plate may remain for a long time in spite of the destructive elements of the disease. Rapid invasion of the entire spongiosa may occur with subsequent collapse of the vertebra. The collated pathological material and the roentgenographic studies show that the disease may occur primarily in the posterior intervertebral joints or facets. Undoubtedly

TABLE V

COMPLICATIONS

	Iowa Series	Questionnaire Series	Total
Suppuration	43	9	52
Involvement of the central nervous system	10	8	18
Metastases	8	6	14
Mortality	15	10	25
Sinus formation	13	16	29
Vascular involvement	4		4
Constitutional * involvement	9		9
Gibbosity	9		9
Extension	13		13
Decubiti	5		5
Spondylolisthesis **	1		1

* The constitutional complications incidental or related to the disease were: diabetes, one; lues, two; uraemia, two; psychosis, two; and amyloidosis, two.

** Spondylolisthesis was observed in an eight-year-old boy who presented a diffuse lumbosacral lesion with slipping forward of the involved fifth lumbar vertebra on the sacrum. Under a mistaken diagnosis of tuberculosis, a Hibbs fusion was performed, at which time the lamina and processes of the fifth lumbar segment appeared to be sequestrated. Sinuses and a humeral metastasis followed, with subsequent recovery. Spondylolisthesis was apparently due to the destructive process, although congenital malformation cannot be ruled out.

these joints do become secondarily involved, especially in chronic extensive lesions of the lumbosacral region. Less commonly, small localized foci occur in the posterior portions of the vertebrae, which respond favorably to prompt treatment. Collateral changes occur, as they do so frequently in osteomyelitic processes in the long bones. Pyogenic osteomyelitis is characterized by its variable pathological manifestations, and spinal localizations offer no exceptions to this rule except possibly for the early and persistent attempts at regeneration that go hand in hand with even the most rapid destructive elements of the disease. Suppuration occurs in the vast majority of cases.

COMPLICATIONS (TABLE V)

The most common and important complication from the surgical viewpoint is suppuration and abscess formation. The formation of abscesses is perhaps the most striking feature of pyogenic osteomyelitis of the spine. These are characterized (as in tuberculosis) by their great size (from even relatively small bony foci) and tendency to gravitate and migrate from their original sites. They may burrow into adjacent tissue spaces, into the vertebral-body surface, or even into the spinal canal. The latter invasion is facilitated by the relative weakness and insufficiency of the posterior longitudinal ligament and the loose attachment of the annulus lamellosus posteriorly. Anterior extension is most common and is favored in practically all body lesions because the flexor surface of the spine is in relation throughout with the viscera, from which it is separated only by the prevertebral space. The muscular and fascial attachments

FIG. 2-A

Osteomyelitis of the second and third cervical vertebrae with a rather marked retropharyngeal abscess, which caused this patient, aged thirty-three, classical mechanical symptoms of embarrassment to respiration, deglutition, and phonation.

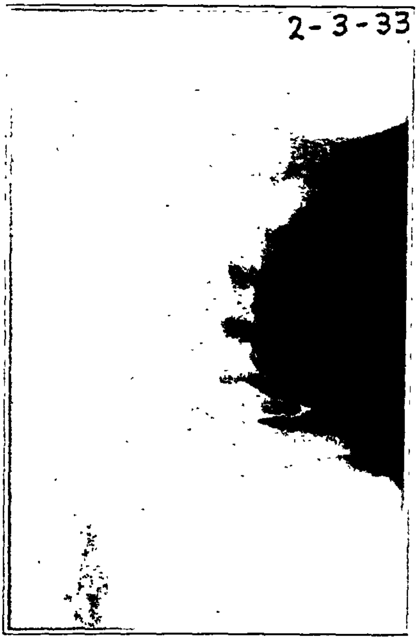

FIG. 2-B

After operation by drainage anterior to the sternomastoid muscle. Excellent recovery.

of the spine form natural cleavage planes for purulent migration. Such migration is most classically illustrated by the more slowly developing tuberculous collections. Those in pyogenic lesions, which may form with amazing rapidity, often perforate these cleavage planes and trace more bizarre routes. They are governed more or less by their segmental level of origin.

The retropharyngeal abscess most often arises from lesions of the upper cervical vertebrae (Fig. 2-A), and may invade the lateral aspect of the neck, perforate the canal, or descend into the posterior mediastinum. One patient reported the sensation of posterior drip long after the lesion had healed clinically. Rarely a retropharyngeal abscess may descend and form a psoas collection. Bulbar compression, incident to the subsequent luxation of the atlas, may occur. Obstruction of deglutition and embarrassment of respiration are the usual symptoms.

In the thoracic region, our interest centers chiefly about the retromediastinal abscess. The intimate connections of the anterior longitudinal ligament with the costovertebral articulation may deflect pus toward the intervertebral and intercostal spaces, localize the abscess, and give rise to typical paravertebral shadows in the roentgenogram. The pleura and pericardium may be perforated.

The most common site of pus in the lumbar region is between the

iliopsoas muscle and its fascia (Fig. 3). Occasionally, the entire psoas muscle is destroyed and displaced by pus. In this connection, it is necessary to emphasize the great clinical importance of isolated occurrences of iliopsoas abscesses and iliopectineal bursitis with no related vertebral pathology. Rupture of the fascia of the psoas muscle or direct perforation of the anterior longitudinal ligament may give rise to the more extensive forms of retroperitoneal abscesses. Not uncommonly, perinephritic collections of pus result from lumbar foci.

The development of pus from the superficial aspects of the sacrum and coccyx results in surface abscesses. Those abscesses which arise from the anterior borders may burrow downward and laterally and simulate the courses taken by other pelvic osteomyelitic foci. Most characteristically, abscesses in the hollow of the lower sacrum and coccyx collect beneath the levator ani muscle and may appear in the subgluteal region, perianally or perirectally. When they originate above the attachment of the levator ani muscle, a subperiosteal abscess arises which may appear as an ischiorectal abscess or laterally above the crest of the ilium or other regions confusing from a diagnostic viewpoint.

Fig. 3

Pyogenic osteomyelitis of the dorsolumbar spine in a female, aged ten years. This roentgenogram illustrates the value of lipiodol injection of sinuses in order to determine the extent of the process as an aid to diagnosis and plan of operative attack. The sinuses were successfully drained by an incision along the anterior iliac crest.

The invasion of the spinal canal and its contents by vertebral osteomyelitis gives rise to the gravest complications of pyogenic spondylitis. (See Table VI.) There were ten instances of spinal-canal complications in the Iowa series, with a mortality of 50 per cent. Most commonly, cord symptoms are due to an extradural abscess which may remain localized or become diffuse. When the dura is perforated, a typical picture of meningitis follows. Our interest was especially aroused by one case of meningitis in a boy, eighteen years of age, with lumbosacral involvement of eight months' duration. Twelve hours after bilateral drainage by the

TABLE VI

ANALYSIS OF COMPLICATIONS DUE TO INVOLVEMENT OF THE CENTRAL NERVOUS SYSTEM

Iowa Series		
Total number of cases		10 (16.6 per cent.)
Males	7 cases	
Females	3 cases	
Segmental focus of vertebral disease:		
Lumbar	5 cases	
Dorsal	4 cases	
Cervical	1 case	
Time of onset of symptoms related to the central nervous system:		
Range—Onset of osteomyelitis to four years afterward		
Average—Six months after onset of osteomyelitis		
Duration of symptoms related to the central nervous system:		
Range—Onset of osteomyelitis to four years		
Average—About nine months		
Symptoms:		
Sensory	5 cases	
Motor	7 cases	
Root pain	1 case	
None	1 case	
Unknown	1 case	
Pathology:		
Meningitis	4 cases	
Infarction of cord	1 case	
Subdural pus	1 case	
Compression	4 cases	
Bacteriology:		
Staphylococcus	3 cases	
Streptococcus	1 case	
Mixed	1 case	
Treatment:		
1. Bone disease:		
Drainage	3 cases	
None	3 cases	
Conservative	4 cases	
2. Spinal canal:		
Aspiration	1 case	
Mortality	5 cases	50 per cent.

laminectomy approach, meningitis developed, as proved symptomatically and by repeated cisternal punctures which yielded pus and a cultural growth of staphylococcus aureus. Death seemed inevitable when the patient was discharged, but he returned completely recovered about one year later, at which time even the spinal fluid was normal.

TABLE VII

TABULATION OF RADIATING OR REFERRED PAIN

	Iowa Series	
Total number of cases	20	(33 per cent.)
Time of onset:		
Immediate	14 cases	
Delayed	6 cases	
Type:		
Bilateral	3 cases	
Unilateral	16 cases	
Alternating	1 case	
Distribution:		
Sciatic	7 cases	
Lumbar	8 cases	
Occipital	1 case	
Local	2 cases	
Superior gluteal	2 cases	
Segmental localization of disease:		
Lumbar	13 cases	
Dorsal	5 cases	
Sacral	1 case	
Cervical	1 case	

In contradistinction to the slowly developing insidious symptoms of compression due to tuberculosis, pyogenic infection usually strikes with dramatic suddenness. Not uncommonly, the spinal roots become involved usually indirectly by being surrounded by inflammatory tissue which leads to oedema and infiltration, giving rise to radiating pain (Table VII). Compression symptoms are usually focal, but may not be evident. In one instance discovered at autopsy, there had been no neurological symptoms. Sometimes extensive general involvement blots out all local and focal signs, and leads to errors in diagnosis. The cord suffers chiefly through compression and inflammatory oedema. Septic thrombosis of the spinal plexus of veins is frequent and occurred in two instances. Therefore, so called suppurative perimeningitis is usually secondary to a vertebral osteomyelitis and is seldom primary.

The most common vascular complication is thrombosis of the iliac veins which occurred in three cases incident to lumbosacral disease. The most interesting occurrence was that of a mycotic aneurysm (Figs. 4-A and 4-B). Extension of the disease is most classically illustrated in the lumbosacral region where sacro-iliac involvement occurred in six instances; in two of these cases the involvement was bilateral. Rupture with extension into the neighboring viscera is not an uncommon complication, particularly in cervical and dorsal foci of the disease.

Gibbosity was noted in only nine instances (15 per cent.). This

complication is not so common as in tuberculosis because rapid extensive bone destruction is infrequent, the disease is often quite rapidly fatal, the recumbent position is quickly assumed by the patient, and the bone-production reactions often occur rapidly. However, there is noted in almost all cases some spinal deviation such as mild scoliosis and loss of the normal physiological curves, due either to limited destructive lesions, or changes in the intervertebral discs, or muscle spasm. There was one instance of spondylolisthesis (Fig. 5).

Spontaneous or postoperative sinus

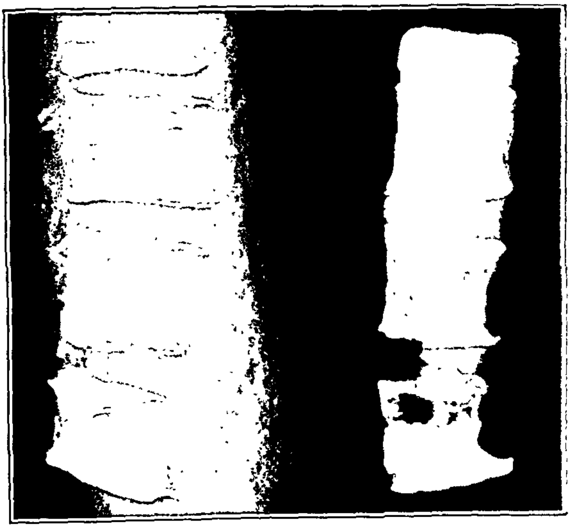

FIG. 4-A

FIG. 4-B

Mycotic aneurysm subsequent to pyogenic osteomyelitis of the third and fourth lumbar vertebrae in a male, aged sixty years, who died on the day of admission to the hospital.

Fig. 4-A: Roentgenogram of the post-mortem specimen, [illegible] erosion on the anterior surfaces of the bodies, due to the aneurysm.

Fig. 4-B: The vertebral specimen and that of the aneurysm. The [illegible] the disc between the first and second lumbar vertebrae [illegible] genogram, but not the extensive destructive primary [illegible]

formation is not uncommon and, when observed about the back or in relation to the spine, should always lead one to suspect a spinal focus of the disease. In the low-back region, these sinuses are often multiple and strongly suggestive of chronicity. It is rather surprising that amyloidosis, as proved at autopsy, occurred in only one instance in spite of the chronicity and seriousness of the disease. This was also suspected clinically in one other case in which the patient recovered, although he presented lumbosacral involvement and a huge liver and spleen for almost two years. Recent studies have tended to show that amyloidosis is not a permanent pathological change and that efforts at therapy should not be abandoned when such clinical evidence is present.

FIG. 5

Spondylolisthesis of the lumbosacral spine, associated with or due to an osteomyelitic involvement of the lumbosacral region, in a male, aged eight years. There appears to be a destructive separation of the neural arch at the "isthmus", but a congenital etiology cannot be ruled out.

Bony metastases occurred in eight instances in the Iowa series. In obscure spinal lesions, such complications often lead to a correct diagnosis. More commonly, multiple soft-tissue abscesses occur which seem to help build up the patient's resistance if his general condition is good or fair at the time, but these may be a terminal phase. It is interesting to record that in one instance, in which the spinal localization was in itself a metastatic lesion, the patient made a correct diagnosis immediately, but several weeks elapsed before his medical advisors were convinced.

The mortality in the Iowa series was fifteen cases (25 per cent.) and ten cases (23.8 per cent.) in the questionnaire series,—a substantial reduction from that of the older literature. The prognosis is materially better than is generally appreciated. A good prognosis depends upon a reasonably early diagnosis and adequate treatment which tends to minimize grave complications. It is interesting to note that this disease is essentially a chronic disorder as in its more common long-bone localizations. The shortest duration of the disease among the patients seen in the hospital was two weeks in a case of acute posterior involvement; the longest was twenty-one years in a case of lumbosacral involvement. The range of duration in the group in which the outcome was fatal was between two

TABLE VIII

GENERAL SYMPTOM ANALYSIS

Iowa Series	
Subjective—	
Onset:	
Acute	26 cases
Subacute	15 cases
Insidious	8 cases
Unknown	11 cases
Constitutional reaction:	
Profound	4 cases
Marked	14 cases
Moderate	24 cases
Unknown	18 cases
Spontaneous pain	60 cases
Objective—	
Tenderness	40 cases
Muscle spasm	26 cases
Loss of weight	25 cases
Superficial abscess	17 cases
Parenteral abscess	14 cases
Oedema and infiltration	6 cases
Hip contracture	17 cases

months and ten years (in one case) and averaged (exclusive of the latter) eight and five-tenths months. In the remaining cases, the duration of the disease ranged between seven weeks (coccyx) and twenty-one years (lumbosacral region), and averaged thirty-seven and thirty-five-hundredths months. All in all, deep-seated inaccessible lesions, extensive destruction, and grave complications are the real causes of fatal outcome.

DIAGNOSIS

The most important requisite for clinical diagnosis of pyogenic spondylitis is a knowledge of the disease. An absolute diagnosis can be made only upon bacteriological or microscopic examination of the tissue, or both. Injection of sinuses with an opaque solution and roentgenographic examination will often lend a clue as to the origin of the infection. Bacteriological and microscopic examination of sinus scrapings, with guinea-pig inoculation of the material, is of great aid in the diagnosis. A presumptive diagnosis may be made upon the clinical course of the disease, the roentgenographic examination, the bacteriological and microscopic examinations of associated primary or metastatic lesions, and the blood culture. In the Iowa series, an absolute diagnosis was made in the majority of cases. From the local pathological viewpoint, tuberculosis [illegible]

most difficult disease to *differentiate*. A discussion of the differential diagnosis involves the following conditions which were mistakenly diagnosed in the Iowa series: tuberculosis, nine cases; appendicitis, four cases; perinephritic abscess, four cases; arthritis of the spine, four cases; pneumonia and empyema, four cases; mediastinal malignancy, three cases; soft-tissue abscess, three cases; meningitis, three cases; sacrolumbar strain, one case; sciatica, one case; mycotic lesion, one case; and ureteral obstruction, one case. In many cases, the diagnosis was made only after an exhaustive study and lengthy observation. A surprising number of cases were diagnosed correctly very early in the course of the disease; some, at autopsy only.

GENERAL SYMPTOMATOLOGY (TABLE VIII)

The onset may be acute, subacute, or insidious. In the very acute cases, the constitutional reaction overshadows the local condition. The apparent discrepancy between the occasional early, small, and even insignificant lesion and the marked constitutional reaction is explained by the severity of the initial primary bacteriemia. Contrary to previous opinion, in the majority of cases the course of the disease becomes subacute or even chronic. *Spontaneous and provoked localized pain is characteristically present in all patients who are mentally alert.* The patient assumes the recumbent position very early and exhibits spinal rigidity due to muscle spasm

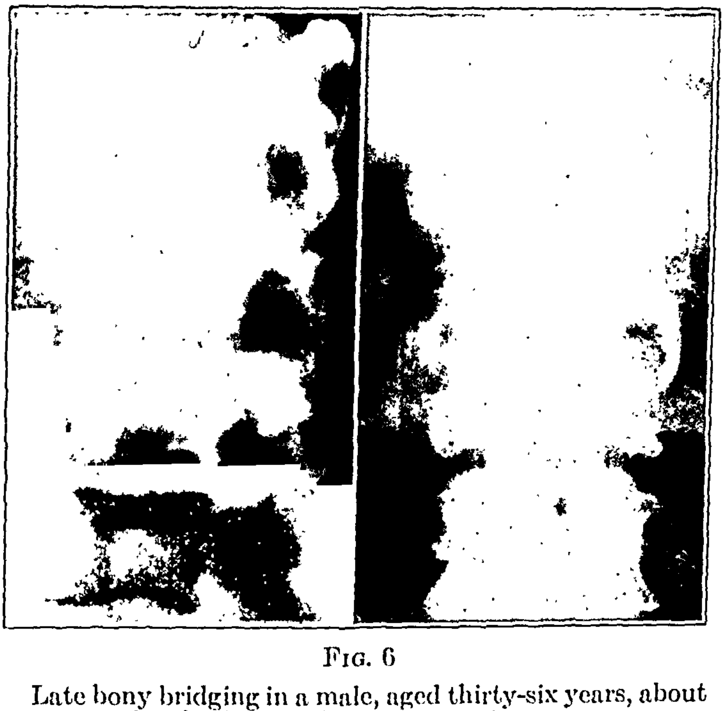

Fig. 6

Late bony bridging in a male, aged thirty-six years, about one year after healing of the operative sinus.

Because of the depth of the lesion, some time may elapse before local signs are definitely demonstrated. Superficial suppurative manifestations appear earlier when the disease originates in the posterior processes. Most commonly there is palpable oedema and infiltration of the back muscles. Posterior superficial fluctuating abscess areas are uncommon in the cervical region where the musculature is dense. In the dorsal and lumbar regions, these abscess areas are not uncommon and are usually at one side of the midline or in the erector spinae sheath. Extensive dissection of the sheath may occur once pus finds its way into this compart-

ment, with attendant destruction of the muscles by pressure atrophy or actual inflammation. Petit's triangle is a favorite site of presentation from lower-back lesions. Occasionally, bilocular superficial abscesses on each side of the midline are noted. Marked tenderness is usually circumscribed; at times, so much so that a minute digital examination must be made in order to detect it. These sites and points of digital-pressure tenderness are remarkable for their tendency to remain localized to the same region in contradistinction to the more shifting sites of tenderness incident to ligamentous strains and sprains, and are almost pathognomonic of pyogenic infection.

Similarly, the spontaneous pain is generally diffuse at the onset and finally becomes well localized to the area involved. The patient assumes various attitudes in an endeavor to obtain relief, but seldom succeeds. Local and general pain is provoked by all movements which produce motion of the spine. In lumbar and low dorsal lesions, meteorism and genito-urinary symptoms are commonly noted. This is probably due to an inflammatory oedema of the prevertebral tissues and the resultant irritation of the sympathetic chain and ganglia. Other symptoms of a visceral nature are governed by the segmental area involved.

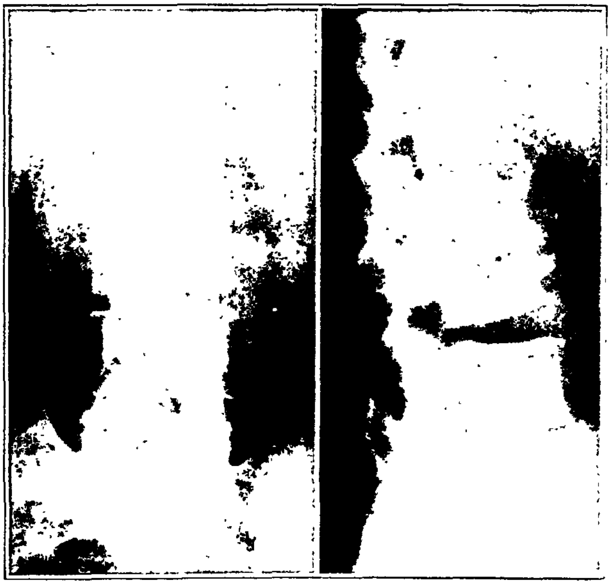

FIG. 7

Destructive lesion of several months' duration in the contiguous portions of the second and third lumbar vertebrae in a male, aged sixty years. Death occurred about four months after operation.

The blood cultures are important as an aid in the differential diagnosis, especially with reference to tuberculosis and visceral lesions. The hemoglobin ranged between 55 and 90 per cent. and averaged about 70 per cent. The red blood count usually revealed a moderate degree of anaemia, but in some cases a marked degree was present. The white blood count ranged between normal and 35,000, showing a moderate rise in the subacute and chronic stages of the disease in the majority of cases. The sedimentation time was as low as thirteen minutes and, as an indicator of the general trend of the disease and the degree of operative risk involved, was utilized to good advantage.

ROENTGENOGRAPHIC FINDINGS

The roentgenogram is indispensable in the diagnosis. Pyogenic spondylitis is differentiated from the tuberculous forms chiefly by the increased density, bony bridges, and exostoses which characteristically occur in the former. The *soft-tissue paravertebral shadows incident to* the attendant oedema may be evident as an early sign and sometimes simulate abscess formation. Abnormalities of the intervertebral spaces, however slight, are important. The trabecular architecture of the affected area becomes obscured in the early stages. The patient must be carefully prepared and the entire spine examined in anteroposterior, lateral, and even oblique views. Many of the most important and earliest roentgenographic changes are noted in the anteroposterior views, particularly static deviations, para-osteal calcifications, localized destructive vertebral-body changes, alterations of the intervertebral spaces, and proliferative changes of all kinds and with varying degrees of bony bridging (Fig. 6). Other changes observed in this series include sequestration, mottling of the vertebrae, and varying degrees of erosion and destructive phenomena. The most destructive phases of the disease in

FIG. 8

Roentgenograms showing osteomyelitis of the fourth and fifth lumbar vertebrae in a male, aged forty-two years. The initial infection was that of the brucella organism. One year later, the patient returned with recurrence of back symptoms. Roentgenographic examination revealed a left psoas abscess and bony bridging between the fourth and fifth lumbar vertebrae. This abscess was drained by a posterior incision; at this time, only the staphylococcus, a secondary invader, was recovered. Originally, the focus was in the posterior articular processes and had now extended to the bodies after secondary infection by the usual pyogenic organisms.

FIG. 9

Pyogenic lesion of eleven months' duration in the lower dorsal vertebrae of a male, aged forty-three years. This case was complicated by empyema. Infiltration shadows show a paravertebral abscess in the soft tissues.

FIG. 10

Extensive lumbosacral and bilateral sacro-iliac osteomyelitis of one year's duration in a male, aged seventeen years. Proliferative changes are negligible. Death ensued, due to local and general complications.

FIG. 11

Localized hypertrophic forms of non-suppurative osteomyelitis in a female, aged twelve years.

the intervertebral disc, in the early stages before contiguous bone has been destroyed, are reflected merely by spacial alterations. The lesion may and does begin in the interarticular joints, and oblique and antero-posterior roentgenograms may reveal pathological deviations here. Because the calcium salts remain and help to localize the lesion in pyogenic bone conditions, atrophic changes do not appear early as a rule. As the

TABLE IX

TREATMENT * AND END RESULTS

	Iowa Series					Questionnaire Series			Total
	Total	Healed	Died	Sinus	Unknown	Total	Healed	Died	
Direct attack	8	5	3	0	0	17	17	0	25
Incision and drainage	27	14	6	5	2	11	5	6	38
Conservative...... .	9	9	0	0	0	9	8	1	18
Laminectomy..... .	0	0	0	0	0	2	1	1	2
No treatment	14	1	5	2	6	2	0	2	16
Spinal fusion.	2	0	1	1	0	1	1	0	3
Total	60	29	15	8	8	42	32	10	102

* No division of treatment into the stages of the disease has been attempted because it has no practical therapeutic significance. Direct surgical treatment indicates an attack upon the bony focus, although in most instances the amount of bone removed was insufficient to affect materially the course of the disease. The postural statics of the spine does not permit the ideal removal of the diseased portions entirely. However, radical operations have been done. Adequate drainage is likely to be established when the affected bone is well exposed.

lesion extends, destructive phenomena are evident. Occasionally, there is a complete or wedge-shaped collapse of the vertebral body. The intervertebral discs are often destroyed (Fig. 7).

The most characteristic feature of pyogenic osteomyelitis is the presence of a reactive new bone formation which produces bony bridging and is always present sooner or later in the disease. This bridging and posterior involvement are the chief differential points in ruling out tuberculosis. New bone formation is often very extensive and results in fusion of the vertebrae, even relatively early. In any case of spondylitis which has been studied by serial roentgenograms over a long period of time, the presence of a localized uniform narrowing of the intervertebral spaces with hypertrophic changes about the margins of the vertebrae (Fig. 11), with or without evidence of abscess formation, should suggest the possibility of pyogenic spondylitis, and the history should be investigated and further examination made from that point of view. The most difficult diagnostic problems are presented by the more benign lesions which go on to very little gibbus formation. In acute cases, small focal destructions close to the disc appear and may rapidly involve the disc, with subsequent narrowing. One case showed multiple cystic areas of destruction. What appeared as a diffuse condensation in some low lumbar lesions in the roentgenogram proved at autopsy to be multiple areas of small healed sclerotic foci of the disease. In the case complicated by mycotic aneurysm, the changes in the vertebrae were due to actual destruction by the osteomyelitic process and, in part, by the erosive action of the aneurysmal pulsations on the anterior contiguous surfaces of the vertebral bodies (Fig. 4).

As a rule, abscess formation can be easily demonstrated. The retropharyngeal collection pushes forward the oesophagus and trachea and appears as a smoothly outlined semilunar distension (Fig. 2-A). The shadows cast by purulent localizations are in part due to the associated marked inflammatory oedema of the paravertebral soft tissues. Paravertebral abscesses show up as clearly as do those of tuberculosis (Fig. 9). Iliopsoas abscesses are clearly depicted as bulging iliopsoas-muscle shadows especially when unilateral (Fig. 8). The chief differential diagnostic points in favor of a perinephritic abscess are obscuration of the psoas muscle, deviation of the spine with the convexity toward the lesion, and absence of spinal changes. In a general way, the roentgenographic findings will depend upon the length of the observation period and the underlying pathology. In the Iowa series, roentgenographic studies were made in forty-eight cases.

TREATMENT AND END RESULTS (TABLE IX)

The uncomplicated case of pyogenic spondylitis does not present any particular problem from the surgical viewpoint. Operative intervention is imperative when suppuration is evident. *When in doubt, however, an exploratory incision should be made!* Orr's principles of adequate drainage and adequate rest serve as an excellent guide in the management of this disease. When suppuration is not manifest and the general course of the disease warrants, bed rest on a frame or plaster bed and general hygienic measures are indicated. A simple adequate incision will suffice for most localizations when an abscess is present. When affected bone exists in the posterior processes, it may be identified at the floor of the operative sinus by characteristic roughening and should be removed. The bodies of the vertebrae should not be attacked except for biopsy purposes for obvious anatomical reasons and because of the dangers of subsequent serious hemorrhage. Posterior involvements should be approached by the most direct routes. In the cervical region, the retropharyngeal abscess is best drained by an incision just anterior to the sternocleidomastoid muscle. Blunt dissection through the alar fascia between the cricoid and hyoid bones (neutral zone of Prentiss) is most effective. A bougie or the finger of an assistant should be placed in the pharynx. In the dorsal region, the retromediastinal abscess requires a procedure such as costotransversectomy or a more lateral rib resection.

Lumbar foci may be attacked posteriorly through incisions just at the lateral border of the erector spinae mass. As in all deep-seated foci, there is a tendency toward premature closure of the wound. It may be necessary to cut some of the contiguous muscle layers transversely to prevent this. Drainage through Petit's triangle is often effective even for sacral lesions, which sometimes require partial or total sacroiliac resection. The coccyx is easily drained directly. When abscesses have gravitated into the pelvis, usually into the iliopsoas sheath, they can be evacuated by an incision along the iliac crest by an extraperitoneal approach. Except

in cases of posterior involvement, the laminectomy approach should be avoided in so far as possible because it exposes the canal and intervertebral foramina to extension contamination. Similarly, indiscriminate aspirations and lumbar punctures may result in complications involving the meninges and the cord. A vaselin pack is lightly inserted into the depths and a generous dressing is applied. It is not necessary to suture any part of the wound. . The patient remains recumbent until the wound has healed and is then allowed up in a brace or cast.

Complications must be dealt with as they arise. Some of these have been pointed out and their treatment suggested. Laminectomy is certainly indicated when compression symptoms occur, due to extradural collection of pus. Laminectomy is also often indicated in the chronic stages of the disease when compression symptoms persist. In some cases of meningeal complication, drainage of the subdural space or, at least, repeated puncture drainage may be necessary.

The surgical pathology is interesting and often confusing. Rough bone in vertebral-body involvement is not easily palpable at operation, due to the contiguous oedema of the paravertebral soft structures. Sometimes the abscess is not located, but copious drainage ensues postoperatively if the wound is properly left open. During operative dissection, the oedema of the soft tissues offers an excellent guide to the surgeon and confirms the diagnosis of deep-seated inflammation. Sequestra not uncommonly find their way to the surface during convalescence.

In the Iowa series, spinal fusion was performed under the mistaken diagnosis of tuberculosis. This procedure has been recommended, however, in selected cases of pyogenic spondylitis, but would seem unnecessary in view of the tendency to spontaneous fusion.

In the ten cases in which death occurred in the questionnaire series, the localization of the lesion was: lumbar body, eight cases; dorsal body, one case; and dorsal arch, one case. There were five extensive multiple segmental foci, and other foci of the disease were present in five cases. Seven patients had positive blood cultures. Two cases were complicated by meningitis and one by puerperal sepsis.

In the fifteen cases with a fatal termination in the Iowa series, the localization of the lesion was: cervical body, three cases; dorsal body, four cases; lumbar body, seven cases; and sacral body, one case. All except two of the patients were adults. More than one segment was involved in all of these cases, and the disease was chronic in the majority of cases. One or both sacro-iliac joints and the sacrum were involved in practically every case in the lower lumbar group. Other factors contributing to a fatal outcome were: bacteriemia and sepsis, eleven cases; amyloidosis, one case; involvement of the central nervous system, five cases; mycotic aneurysm, one case; obstruction to the upper respiratory system, three cases; visceral complications, ten cases; thrombosis of the pelvic veins, four cases; and the presence of other foci of the disease in four cases.

SUMMARY AND CONCLUSIONS

More discriminating diagnoses have resulted in a surprising increase in the prevalence of pyogenic osteomyelitis of the spine. The large series observed at the University Hospitals, Iowa City, may be partially accounted for by the rural environment from which most of these patients came, it being generally stated that pyogenic bone infection is most common in such districts. Almost 1 per cent. of all cases hospitalized in these Clinics is due to some form of pyogenic osteomyelitis. There is no evidence to show that pyogenic bone infections in general are gradually diminishing or becoming more benign in this country, as was recently observed by a British writer in his clinic groups.

The diagnosis of pyogenic spondylitis can be made reasonably early if the disease is considered at all. In fact, a knowledge of the disease is the primary factor in the diagnosis. Clinically, there occur acute, subacute, and chronic forms which are not conditional upon the extent of the lesion, but upon the associated bacteriemia and other complications,—particularly the rapidity with which suppuration and abscess formation ensue. The disease is common in adults, although it predominates in the second and most active decade of life. Any part of the vertebral system may be affected, but essentially the disease attacks the bodies of the vertebrae sooner or later, especially if prompt adequate treatment has not been instituted.

The mortality is still too high. It may be axiomatically stated that operative intervention is imperative, as soon as the diagnosis is made with a reasonable degree of certainty, when suppuration is present or suspected in the acute or chronic stages of the disease. The extent of the operation is necessarily limited by the operative risk and the important static function of the spine. The secondary purulent infiltrations must continue to demand our primary surgical considerations. The adequate evacuation and continued drainage of such collections offer great difficulties, and, in general, can best be accomplished by observing Orr's principles. It is an impressive lesson to observe at autopsy the presence of huge pelvic and psoas abscesses after one has thought that the local situation had been adequately taken care of. On the other hand, there are several patients in this series who, following a prolonged period of suffering and discouragement, are well only because of a persistent repeated attack upon the disease. The lumbosacral lesions are particularly difficult to evaluate clinically, especially after one or more of the sacro-iliac joints have become involved by extension (Fig. 10). The primary spinal focus requires the first attention of the surgeon, and any pelvic purulent collection or infiltration should be attacked from every surface possible in order to bring about its successful evacuation and continuous drainage.

No other location reveals so clearly as the spine that we are dealing primarily with a septicaemia in the acute stages of pyogenic osteomyelitis. The local skeletal manifestations of the disease are of [illegible] importance until suppuration has occurred. Patients who die in the [illegible]

acute stages do so because of the intense general sepsis. It is fortunate that, in dealing with spinal foci, we need not concern ourselves with the old debate relative to the early attack upon the bony focus in acute pyogenic bone infection. In treating these lesions, the rule of adequate drainage and rest, as soon as the diagnosis is made, should be followed until further knowledge about the relationship between the port of infectious entry, the septicaemia, and the local condition contra-indicates such measures.

The writer wishes to express his appreciation to the members of the profession who were kind enough to fill out and return the questionnaires on this subject.

SACRARTHROGENETIC TELALGIA

II. A Study of Sacral Mobility

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This article is the second of a series of five *. It is based upon additional analyses of the 506 records used in the first article and upon the records of 144 normal male students whom we studied as controls during their routine physical examinations for entrance to the University of California. Its scope is limited to a study of the mobility of the upper sacral joints, and its purpose is to show that sacro-iliac mobility is demonstrable *in vivo*, as well as in autopsy material.

In reviewing the literature, we have encountered very little difference of opinion in regard to the mobility of the sacrolumbar articulation. The sacrolumbar zygapophyses may resemble those between the adjacent dorsal vertebrae, or they may vary through 90 degrees of revolution[f] until they resemble those between the lumbar vertebrae. The type and extent of sacrolumbar motion must vary with the shape of the articular facets, but we have not found any author who doubts that the normal articulation is movable. Abnormal mobility may cause strain—that is, pathological tension—in the extra-articular sacrolumbar ligaments. In the first article of this series[11], we showed that such tension causes sacrarthrogenetic telalgia.

Despite arguments to the contrary, the normal sacro-iliac articulation is a diarthrosis. This fact has been established beyond all possibility of informed doubt by the anatomical and pathological studies of Meyer, Klein, Goldthwait and Osgood, Albee, Derry, Brooke, Sashin, and others. These authors have shown that the normal sacrum takes part in anteroposterior (flexion and extension) movements of the spine and that its average mobility in the cadaver is 4 degrees. Clinical records of sacro-iliac mobility are less easy to find. A few surgeons, like Ryerson, have demonstrated sacro-iliac mobility by manipulating these joints during surgical exposure. Chamberlain and others have determined sacro-iliac mobility by roentgenographic measurements of vertical mobility at the symphysis pubis, but these have been studies of abnormal joints, and we have not found in the literature any clinical measure of normal sacro-iliac motion. It is not difficult to demonstrate anteroposterior motion of the sacrum in two lateral roentgenograms taken with the subject recumbent and with the spine in the positions of acute flexion and hyperextension.

* [illegible]

III. [illegible]
IV. [illegible]
V. [illegible]

but this method is not suitable for rapid examinations of large groups of normal subjects.

The axis of normal sacral motion usually is described as a line that parallels the plane of the base of the sacrum and passes through the body of the second sacral vertebra in the transverse plane of the trunk [7]. Such a line crosses each sacro-iliac joint among the interosseous ligaments close to the sacral tuberosity, and lies at the approximate center of the circle that would be formed by continuing the rough arc of the upper two-thirds of the auriculate articular cartilage (Fig. 1). Movements of the sacrum about this transverse axis are analogous to flexion and extension of the spine.

FIG. 1
Lateral view of the sacrum.

Despite the fact that the sacrum is a part of the vertebral column and, therefore, might be expected to take part in rotatory and lateral bending movements of the spine, we have not found any author who describes these types of sacral motion. The shapes of the sacro-iliac joints and their rough interlocking surfaces seem to deny the sacrum any movement about its longitudinal (rotation) or anteroposterior (lateral bending) axes.

In the presence of an intact symphysis pubis, all motions of the innominate bones about the transverse axis of the sacrum, or about the transverse axes of the hip joints, must be paired motions. Antagonistic

motions of this type would rupture the symphysis and are possible only when the symphysis is relaxed or torn. When the weight of the body is borne upon the lower extremities, the paired movements of the innominate bones are flexion and extension about the hip joints. In these movements the sacrum takes little part, since the weight of the trunk, acting through the lordotic lumbar spine, holds it almost continually in a position of flexion *. Movements of the pelvis, other than flexion and extension about the hip joints, are associated with unpaired, antagonistic motions of the innominate bones about a transverse axis that passes through the center of the symphysis pubis. This axis lies at the approximate center of the circle that would be formed by continuing the rough arc of the lower two-thirds of the auriculate cartilage (Figs. 1 and 2). We have checked this type of iliac motion by measurement of antero-posterior and lateral roentgenograms taken with the subjects in the standing position, but we have devised a much more convenient method of measuring it by means of an *inclinometer*.

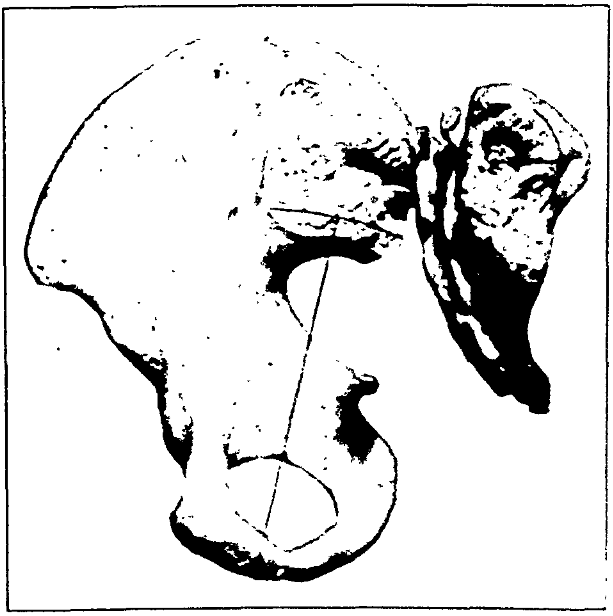

FIG. 2
The centers of sacro-iliac motion.

This instrument (Figs. 3 and 4) is made from a carpenter's calipers to which ball points, a small pendulum, and the scale of a transparent protractor have been fitted. The rod, upon which the protractor and pendulum are mounted, slides through the friction post and continually bisects the space between the arms of the calipers. Thus, the plane of the surface of the protractor always is parallel to a line that connects the tips of the calipers. The examiner applies one tip of the

* Six muscles act directly upon the sacrum. All of these [illegible] of the spine and innominate bones. The [illegible] ilíacus act as flexors. The gluteus maximus, the [illegible] extensors. None of these muscles arises from the sacrum [illegible] tional and usually a more extensive origin from the [illegible] maximus has sufficient strength or leverage to [illegible] cause the sacrum to extend. Its leverage [illegible] act upon the sacrum alone [illegible] hips, since these muscles [illegible] insertions.

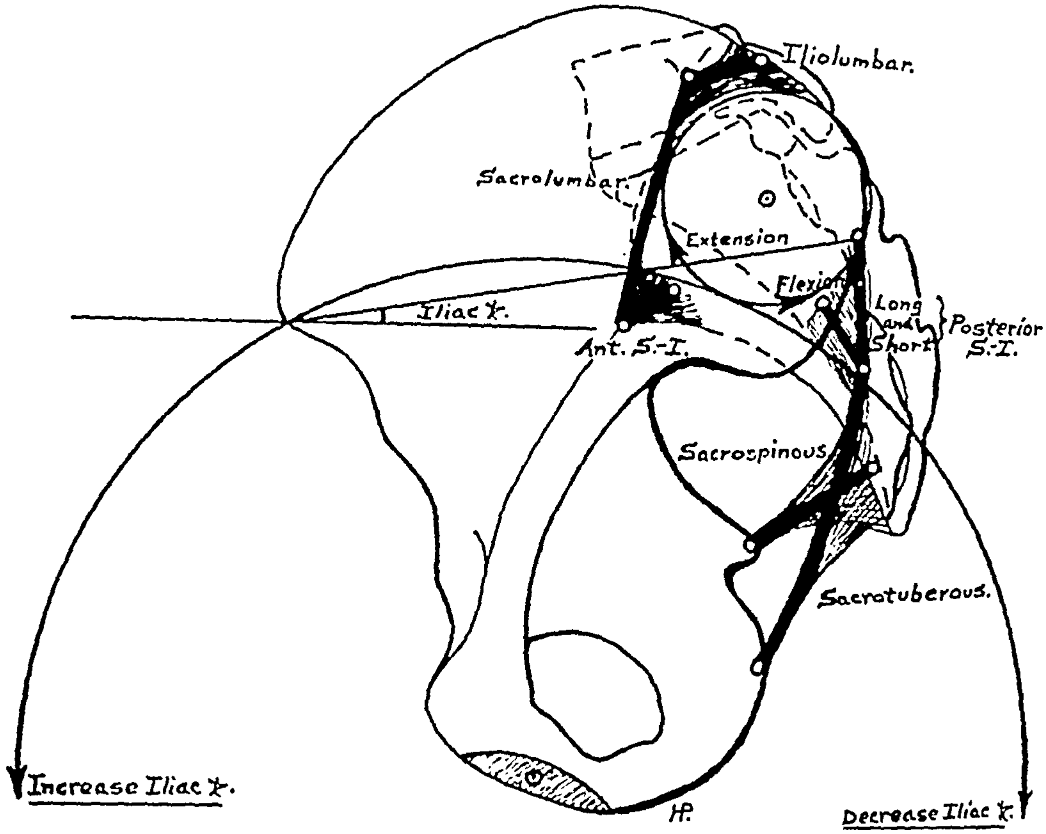

FIG. 5
The extra-articular ligaments of the upper sacral joints.

immediately oppose any attempt to increase the angle of inclination, and the sacro-ischial ligaments immediately oppose a decrease. However, flexion of the sacrum will relax the sacro-iliac ligaments and allow the ilium to rotate forward; extension of the sacrum will relax the sacro-ischial ligaments and allow the ilium to rotate backward. When antagonistic mobility of the two ilia occurs, it thus creates a need for flexion of the sacrum on the side of increasing iliac inclination, and a need for extension of the sacrum on the decreasing side. The sacrum obviously cannot flex and extend simultaneously; it can do only one of these acts, and the weight of the trunk tends to hold it in flexion. Thus, as we have noted in the summary of our examinations of normal males, the ilium that is being rotated forward usually shows a greater excursion than the one that is being rotated backward, and the increased lumbar lordosis reflects the increased flexion of the sacrum.

When an ilium rotates forward about the symphysis pubis as a center, its articular surface, which is slightly behind the center of motion, travels on a rising arc and is carried somewhat upward, as well as forward. Similarly, rotation of the ilium backward causes the articular surface to be translated backward and downward. When antagonistic iliac mobility occurs, the sacrum cannot remain suspended in mid-air, but is forced by gravity to follow any *downward* or *forward* motion of the ilia. Therefore, the articular surface of the sacrum, on the side of the ilium that is rotating

forward, accompanies the articular surface of that ilium in its *forward* and upward movements. The opposite side of the sacrum, in a like manner, accompanies the ilium that tends to rotate backward and *downward*. Thus, the sacrum is caused to bend laterally and to rotate away from the side on which the angle of inclination is increasing. The antagonistic movements of the ilia and the associated movements of the sacrum can be demonstrated quite easily by measurements of roentgenograms, and we have checked our inclinometric figures by this method.

From the foregoing, it is apparent that we must divide sacral mobility into two types:

1. Flexion and extension, in which the sacrum is the moving member and the ilia are fixed.

2. Lateral bending and rotation, in which the ilia are the moving members and the sacrum follows passively.

It should be emphasized that *lateral bending and rotation normally do not occur alone, but as correlated movements*, and that in this respect the sacrum does not differ from the rest of the presacral vertebrae, perhaps excepting the atlas and axis. We have found, by inclinometric and other measurements, that this second type of sacro-iliac motion regularly accompanies all lateral bending and rotatory movements of the trunk (Table I). Because the volitional element is greater in these movements than in the reflex compensation for a lengthened leg, we have not used them for routine tests *.

The problem of measuring separately the mobility of either sacro-iliac joint, when both joints are movable, has proved to be an insoluble one to date. In cases of bilateral sacro-iliac ankylosis, the measurements of iliac mobility regularly have shown less than 2.0 degrees of total antagonism (which establishes the maximum error inherent in this method). In cases of unilateral sacro-iliac ankylosis, antagonistic mobility of the ilia has been found to be identical on the two sides, or to have differed by less than 2.0 degrees. In our group of normal males, the average antagonistic mobility of the left ilium was 4.8 degrees, while that of the right

* The relation of the dominant hand and eye to iliac mobility is interesting and perhaps important. When we made our measurements of iliac mobility in the group of normal students, we also made records of their handedness and eyedness by Quinan's method[12] and discovered the following facts:

1. The dominant eye, primarily, and the dominant hand, secondarily, are associated with a decrease in the iliac inclination on the same side in normal stance.

2. Unilateral double dominance is associated with:

a. The largest difference between the two angles of inclination in normal stance, the doubly dominant side tending to show the smaller angle;

b. The largest excursion of one ilium, usually the one on the doubly dominant side when that side is lowered;

c. The largest net change in the inclination of the pelvis as a whole, because the less mobile ilium frequently follows rather than opposes the rotation of the more mobile one.

3. Right-eyedness is associated with the largest total antagonistic mobility of the two ilia.

4. Left-handedness is associated with the largest discrepancy between the individual excursions of the two ilia.

5. The largest net change in the inclination of the pelvis as a whole is associated with the smallest total antagonistic mobility of the two ilia [illegible].

TABLE I

NORMAL MECHANICS OF THE PELVIS AND SPINE IN THE ERECT POSITION
(FLEXION AND EXTENSION ARE NOT INCLUDED BECAUSE THEY DO NOT CAUSE TORSION OF THE PELVIS)

Effect Upon	Short Right Leg, or Lift under Left Foot	Short Left Leg, or Lift under Right Foot	Bending of Trunk to Left, and Shifting of Pelvis to Right	Bending of Trunk to Right, and Shifting of Pelvis to Left	Rotation of Trunk to Left, and of Pelvis to Right	Rotation of Trunk to Right, and of Pelvis to Left
Left Acetabulum	Up	None	Up	Down	(Down)	(Up)
Right Acetabulum	None	Up	Down	Up	(Up)	(Down)
Pelvic Tilt	Right	Left	Right	Left	Left	Right
Pelvic Shift	Left	Right	Right	Left	(Left)	(Right)
Left Iliac Inclination	(Decreased)	Increased	Increased	(Decreased)	(Decreased)	Increased
Right Iliac Inclination	Increased	(Decreased)	(Decreased)	Increased	Increased	(Decreased)
Sacral Motion—Longitudinal Axis	Left rotation	Right rotation	Right rotation	Left rotation	Left rotation	Right rotation
Sacral Motion—Anteroposterior Axis	Left lateral bend	Right lateral bend	Right lateral bend	Left lateral bend	Left lateral bend	Right lateral bend
Lumbar Curve Convexity	Right	Left	Right	Left	Left	Right
Rotation of Pelvis—Longitudinal Axis	Left	Right	Right	Left	(Right)	(Left)
Dorsal Curve Convexity	Right	Left	Right	Left	Right	Left
Rotation of Shoulder Girdle—Longitudinal Axis	Left	Right	Right	Left	Left	Right
List	(Left)	(Right)	Left	Right	Right	Left

The parentheses in the above columns indicate weak actions that always are present, but that may be neutralized or overcome by the dominant actions.

ilium was 6.2 degrees. This represents a total antagonistic mobility of 11.0 degrees. In our group of cases that showed sacrarthrogenetic telalgia, the antagonistic mobility of the ilia was found to be increased; its average measurement was 7.0 degrees for the left ilium, 7.6 degrees for the right ilium, and the total was 14.6 degrees *. A comparison of the two groups shows that in the group with sacrarthrogenetic telalgia the average mobility of the left ilium was increased by 2.2 degrees, or 46.0 per cent.; that of the right ilium was increased by 1.4 degrees, or 23.0 per cent.: and the average total mobility was increased by 3.6 degrees, or 33.0 per cent. If one will imagine the effect of an increase of 33.0 per cent. in the mobility of any joint with which he is completely familiar, he will recognize the possibilities of strain that such abnormal mobility entails.

The ilium on the side of maximum pain may show an increased mobility or a decreased mobility, but, when we consider that in this series the average increase in mobility of the left ilium was 23.0 per cent. greater than that of the right, the following figures become significant. Tenderness of the posterior sacro-iliac ligaments was 14.0 per cent. more frequent on the left side than on the right. The patients complained of telalgia originating in the left sacro-iliac joint 17.0 per cent. more often than in the right. Prone-knee flexion [10] was more limited on the left side 37.0 per cent. more often than on the right. Supine straight-leg raising was more limited on the left side 41.0 per cent. more often than on the right.

In the first article of this series, we showed that sacrarthrogenetic telalgia in the lower extremities is caused by pathological changes in the tension of the extra-articular ligaments of the upper sacral joints. At that time we omitted all consideration of sacro-iliac mobility. The parallelism between the incidence of sacrarthrogenetic telalgia, abnormal mobility of the ilia, tenderness of the sacro-iliac ligaments, the patient's opinion of the source of his pain, and the results of those tests which tend to increase the tension of the sacro-iliac ligaments is too striking to be fortuitous. We feel that abnormal sacro-iliac mobility is not only a regular concomitant, but also a potent cause of the abnormal ligamentous tension that produces sacrarthrogenetic telalgia.

CONCLUSIONS

1. Sacro-iliac mobility can be demonstrated *in vivo* by measuring the movements of the ilia.

2. In the standing position, all motions of the trunk, with the exception of flexion and extension, normally are associated with unpaired, antagonistic movements of the ilia about a transverse axis that passes through the center of the symphysis pubis.

* Only the males were considered in computing this average, in order to make the figures more accurately comparable. The average age of the individuals in this group was considerably greater than in the normal group, so that, all other factors being equal, the mobility in the normal group would have been the greater.

3. Rotation and lateral bending of the sacrum normally do not occur alone, but as correlated motions that are coincidental to antagonistic movements of the ilia.

4. The positions of the ilia in normal stance, as well as their relative mobility, are affected by the dominant eye and hand.

5. The average antagonistic mobility of the male ilia is found to be increased 33.0 per cent. above normal in those subjects who complain of sacrarthrogenetic telalgia.

6. Abnormal sacro-iliac mobility is a potent cause of the abnormal ligamentous tension that produces sacrarthrogenetic telalgia.

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LUMBOSACRAL FUSION FOR THE RELIEF OF LOW-BACK PAIN

A Report of Thirty-Five Cases

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From the MacAusland Orthopaedic Clinic

The painful low back, orthopaedic in nature, which fails to respond to conservative measures still presents a problem. While operative fusion of the spine has assumed a prominent place in the treatment of these difficult cases, the published reports of spine fixations for this affection are comparatively few, and many attempts have given unsatisfactory results. It is not easy to obtain a solid fixation of the lumbosacral region. The successful fusions in thirty-two of the thirty-five cases that form the basis of this paper were due to the introduction of a larger amount of bone for grafts than is provided for by the usual technique.

From the diagnostic standpoint this report will substantiate the view held by many observers,—namely, that anomalies of the fifth lumbar vertebra or postural variations at the lumbosacral junction are often the underlying factors in the causation of low-back pain. The complete relief that followed fusion of the lumbosacral junction in the series of cases to be reported proved to the writer's satisfaction that the site of pain was localized in this area.

SUMMARY OF CASES

The series of thirty-five cases extended over a period of approximately five years.

Eighteen of the patients were males and seventeen were females. This equal distribution of the affection between the sexes would point to anatomical irregularities as factors in the etiology of back pain.

The ages of the patients at the time of operation ranged from thirteen to sixty-one years. Sixty per cent. were between twenty-one and forty years of age at the time of operation, and, in all but one case, symptoms had been experienced for more than a year before the spine was fused. Eight patients were between thirteen and twenty years of age. It is seen from this age distribution that low-back pain is experienced more commonly during the active years of life.

The back pain was usually associated with pain radiating down one or both thighs, and in many cases there was an area of pain on the outer side of the calf just below the knee joint. The pain in the back was generally experienced at the muscle attachments on the [illegible] and seemed to radiate over the sacro-iliac region. There were [illegible] in which the chief complaint was pain referred to the [illegible] cases, when the patients were questioned [illegible] suffered from back pain sometime in the past.

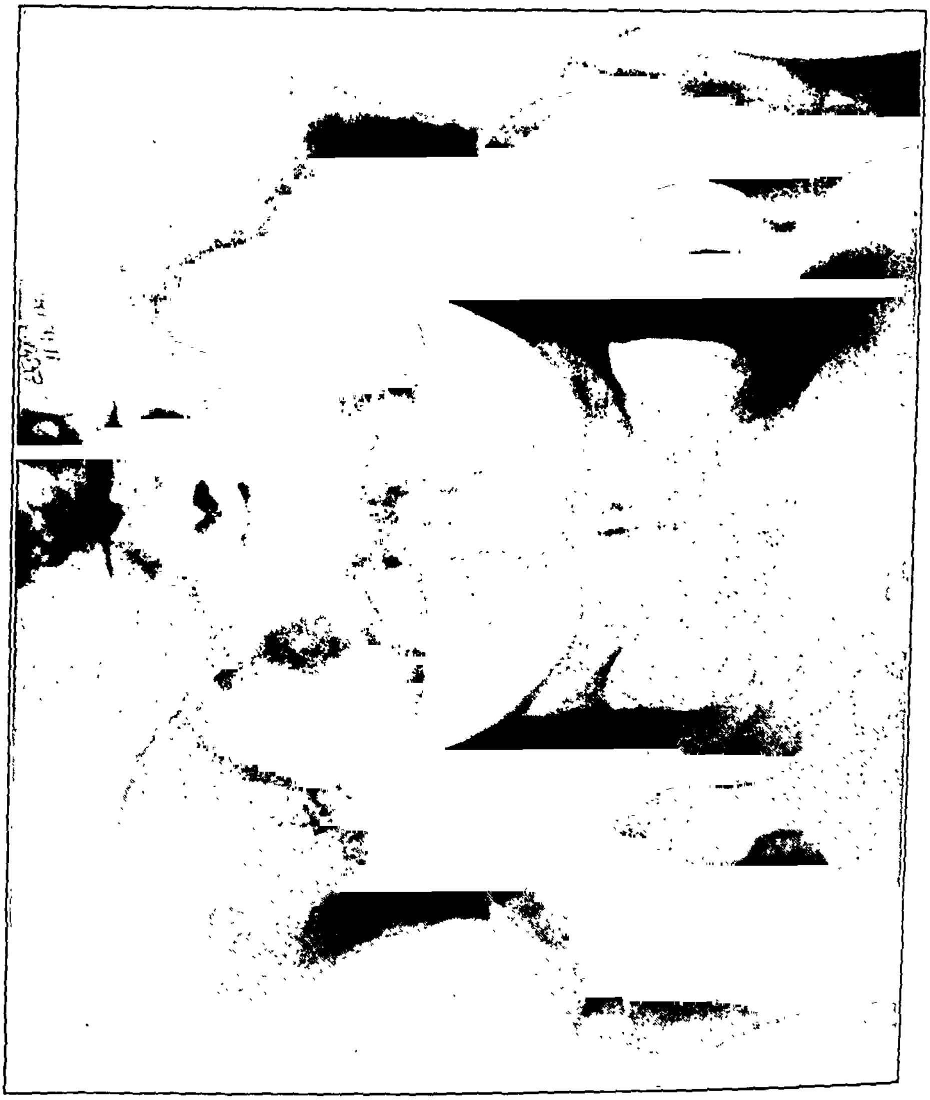

FIG. 1-A

FIG. 1-B

W. B. Anteroposterior and lateral roentgenograms before spine fusion, showing marked blunting of the facets of the fifth lumbar vertebra. Note the horizontal sacrum.

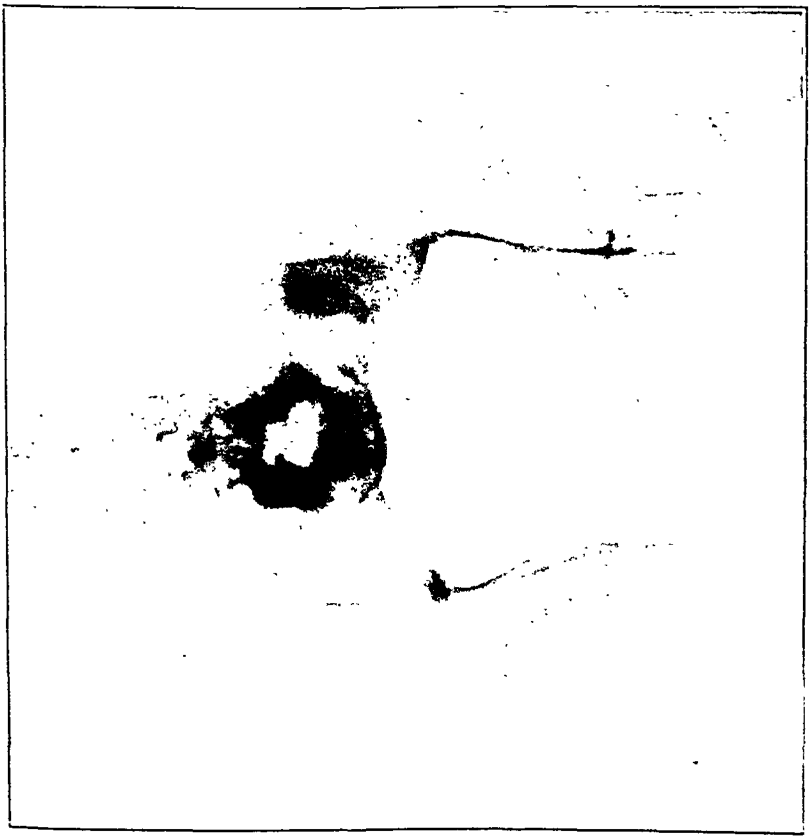

Fig. 2-A

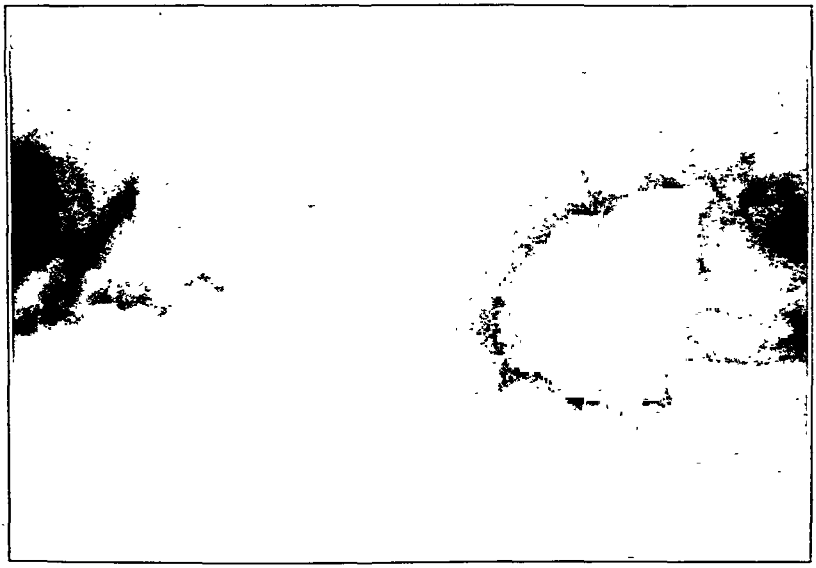

Fig. 2-B

W. B. Postoperative roentgenograms nine months after fusion.

In the majority of cases, the onset of symptoms was ascribed by the patient to a strain incurred either while lifting a heavy object or in falling, and recurrent attacks of disability had been experienced over a period of several years. At some time in the course of treatment, all cases had been diagnosed as sacro-iliac disturbance, and all patients had undergone the customary medical and conservative orthopaedic treatment.

The determination that mechanical derangements and pathological changes existed in the lumbosacral region was made from a study of the roentgenograms. It is unnecessary to review in detail the lumbosacral junction with its numerous anatomical variations and its vulnerability to stress and strain; medical literature contains ample discussions of all phases of the subject. In this particular series of cases, the predominant anatomical defects and variations of the lumbosacral region considered to be potentialities of disturbance were, in the order of relative frequency, as follows:

Slumping of the fifth lumbar vertebra and impingement posteriorly on the sacrum		7 cases
Asymmetrical facets, or variation in the positions of the articular facets		8 cases
Facets asymmetrical in outline	3 cases	
Facets asymmetrical in position	4 cases	
Marked blunting of the facets of the fifth lumbar vertebra (Figs. 1-A and 1-B)	1 case	
Incomplete closure of the posterior neural arch with spondylolisthesis		7 cases
Sacralization		2 cases
Also in combination with asymmetrical facets	1 case	
Also in combination with horizontal sacrum and slumping of the fifth lumbar vertebra	1 case	
Perpendicular sacrum		3 cases
Impingement of spinous processes (Fig. 3)		1 case
		28 cases

These defects were seldom isolated, but existed in combination with various other structural abnormalities. In the first group of cases, there were two in which, in addition to the slumping of the fifth lumbar vertebra, the sacrum was horizontal. In the second group of cases, sacralization or defects of the sacrum accompanied the irregularity of the articular facets.

Spondylolisthesis, in the third group of cases, was associated with lack of bony fusion of the posterior neural arch in the fifth lumbar vertebra on one or both sides. In four of the seven cases, the laminae were freely movable. In one case—that of the thirteen-year-old patient—the laminae were completely separated centrally and were only partly ossified and in two distinct sections (Fig. 4). In all seven cases, the origin of the spondylolisthesis seemed to be definitely congenital. In only one case did injury enter in as a factor, and even in this exceptional case the part that trauma played is questionable as the case was one under litigation. The clinical picture did not differ in any special respect from that of the other groups, except that physical examination revealed the typical lumbar lordosis and

FIG. 3

I. K. Before spine fusion. Note impingement of the spinous processes.

prominent spinous process of the sacrum. The longest duration of symptoms in these cases was six years and the shortest was six months.

In only one of the cases of sacralization had actual fusion of the transverse process of the fifth lumbar vertebra taken place; this was a case of unilateral fusion with marked torsion of the spine toward the sacralized side. Sacralization, whether complete or incomplete, renders the lumbosacral area susceptible to strain. Listing develops, first from a lumbar torsion, to which later is added a compensatory dorsal curve. The advantage of recognizing a sacralization early in life is apparent.

In one case, the roentgenogram showed anomalies of the spinous processes with some fusion of the fourth and fifth lumbar vertebrae, which had already been established by nature. There were also marked arthritic changes between these vertebrae. The patient was a man sixty years of age and he had suffered from pain for over twenty years. Complete relief followed fusion of the lumbosacral region.

When any of the structural changes already described exist in the lumbosacral region, it is easily understood how this junction is thrown open to strain. Sudden trauma, occupational strain, excessive weight, or faulty weight-bearing aggravate the normal strain, with a consequent development of arthritic changes. Muscle spasm sets in to protect the affected area, but, in turn, it creates further strain and faulty weight-

bearing, which lead to the development of additional irritative changes. It is a vicious circle!

Occasionally, a case is seen of a purely mechanical impingement of the fifth lumbar vertebra without arthritic changes. It is noted that patients with such lesions complain of pain while standing, but often, after lying down for a period varying from fifteen minutes to an hour, they secure relief. The mitigation of pain in these cases is in contrast with the continual pain experienced in cases in which irritative arthritic changes have occurred.

In only seven of the thirty-five cases were factors other than congenital abnormalities the apparent causes of the back pain. Arthritis, toxic

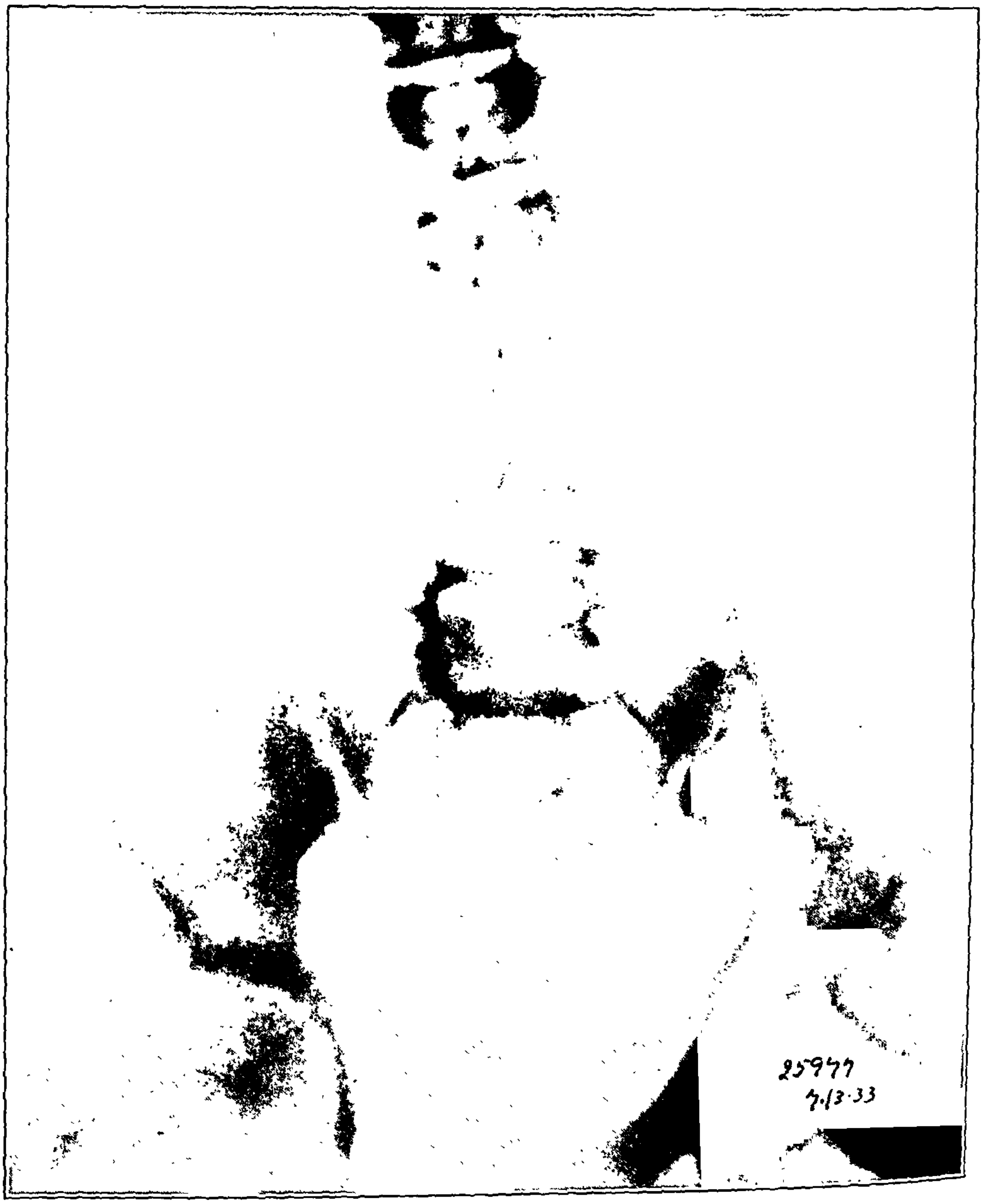

Fig. 4

A. G. Preoperative roentgenogram, showing spondylolisthesis in a boy, aged thirteen. The laminae are completely separated posteriorly, are only partly ossified, and are in two distinct sections. The sacrum is horizontal.

Fig. 5-B

Fig. 5-A

A. G. Postoperative roentgenograms, one year after fusion.

in origin, was the causative agent in three cases; the process started low down and spread upward. In three cases, abnormal static conditions, caused by a short leg, resulted in the development of structural curves with accompanying low-back pain. In the one remaining case, a severely marked list, of long-standing and associated with irritative joint changes,

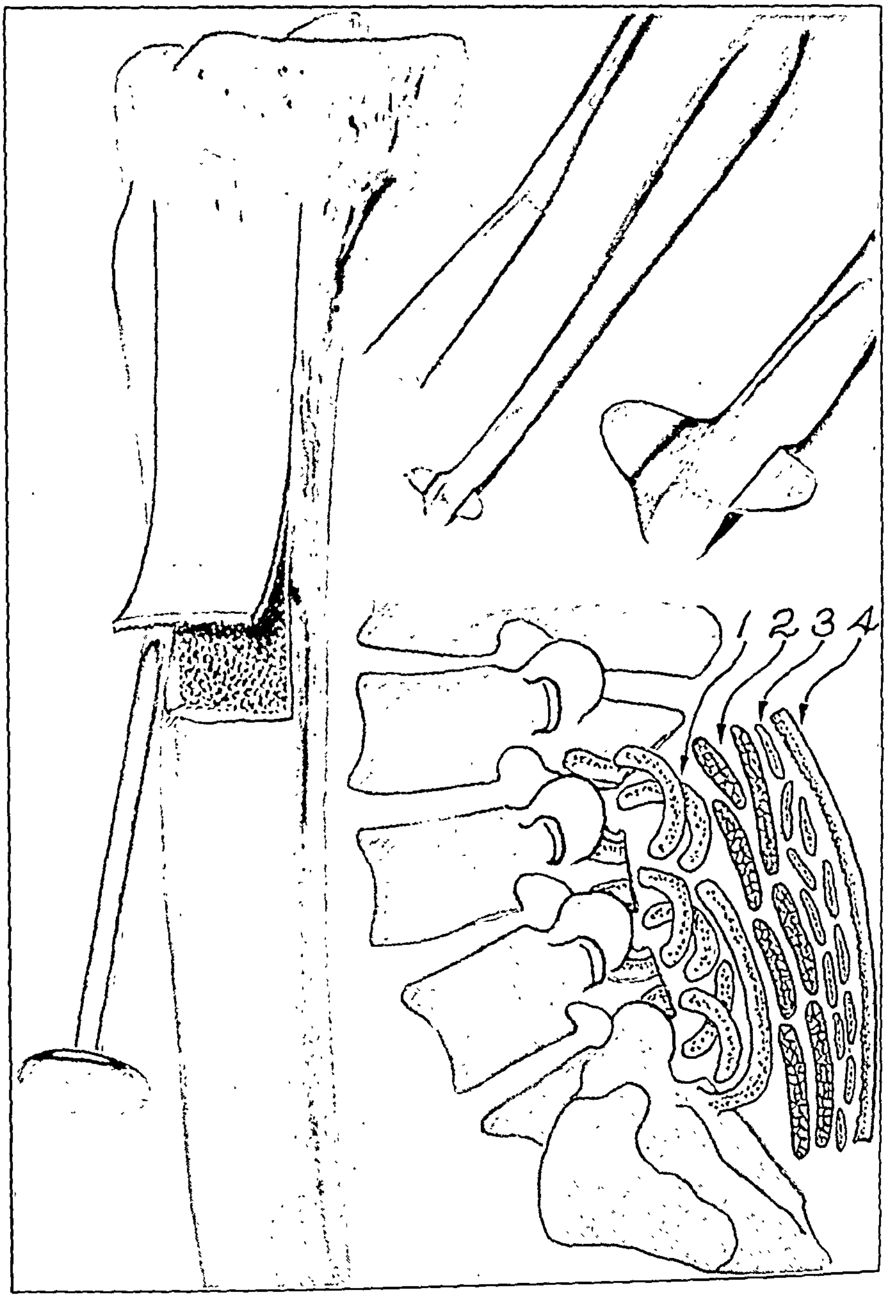

FIG. 6

Spine fusion, showing:
Left: Removal of osteoperiosteal grafts from the tibia.
Upper Right: Special instruments used for turning up grafts from the laminae and sacrum and obtaining cortical chips of bone from the tibia.
Lower Right: The various layers of grafts in place:
1. The grafts turned up from the laminae and sacrum;
2. The cut-up spinous processes;
3. The cortical slivers of bone obtained from the tibia;
4. The broad grafts obtained from the tibia.

had followed trauma.

The explanation of the causation of pain is still being sought. Mitchell, in his excellent article on "The Lumbosacral Junction", described fully the relation between nerve-root distributions and such derangements as spondylolisthesis, slumping of the fifth lumbar vertebra, and an acute lumbosacral junction. In brief, the pain is presumably due to the tension on the nerves produced either by congestion or by stretching. In the case of the nerves of the fifth lumbar vertebra, which are of fair size and have relatively small foramina through which to pass, it is easy for the inflammatory reaction to produce pressure. Because of the tendency of the irregular anatomical structures to twist, it is also possible that torsion causes stretching of the nerves. The fact that many patients obtain relief by lying down would seem to bear out the theory that some mechanical factor, such as is produced by torsion, may disturb the nerves in some cases. Apparently, bony impingement without motion does not enter into the production of pain, for, although deformity is not corrected at the time of operative fusion, the patient obtains relief.

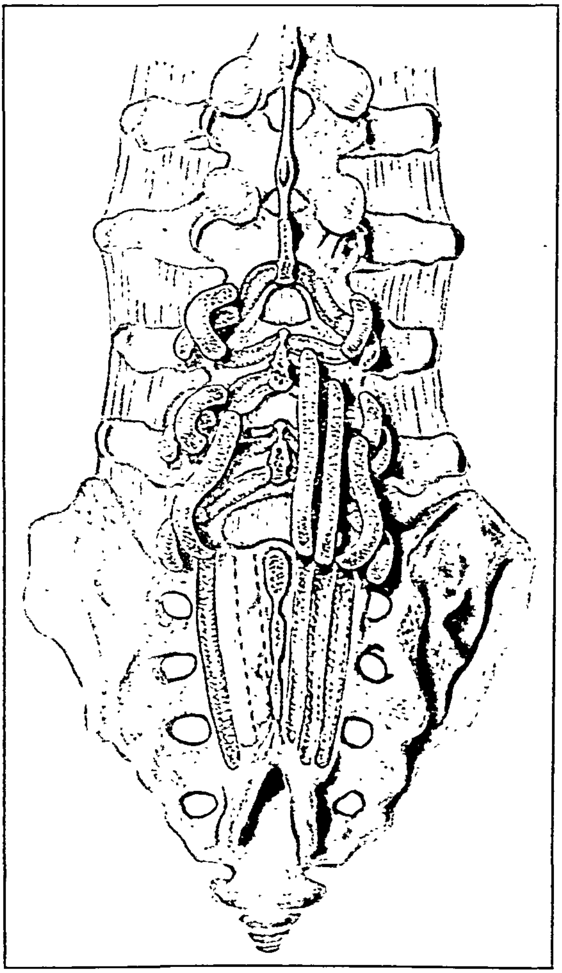

FIG. 7

Spine fusion, showing heavy chip grafts turned up and down from each lamina and overlapped. Grafts are also turned up from the sacrum.

TECHNIQUE OF OPERATION

The patient is prepared for operation in the usual manner. One shoulder is raised on a rest to bring the chest off the operating table, in order not to embarrass respiration.

A curved skin incision is made over the area to be fused, and the line is so placed that it does not lie over the fascial incision, in order to minimize the danger of infection.

The fascia is cut directly over the spinous processes.

The spinous processes of the fourth and fifth lumbar vertebrae and, as a rule, of the third lumbar vertebra, as well as those of the sacrum, are carefully denuded in order to obtain good exposure. A great deal of time need not be used in removing all the ligamentous attachments and tips of the processes. The laminae are thoroughly cleaned as far back as possible.

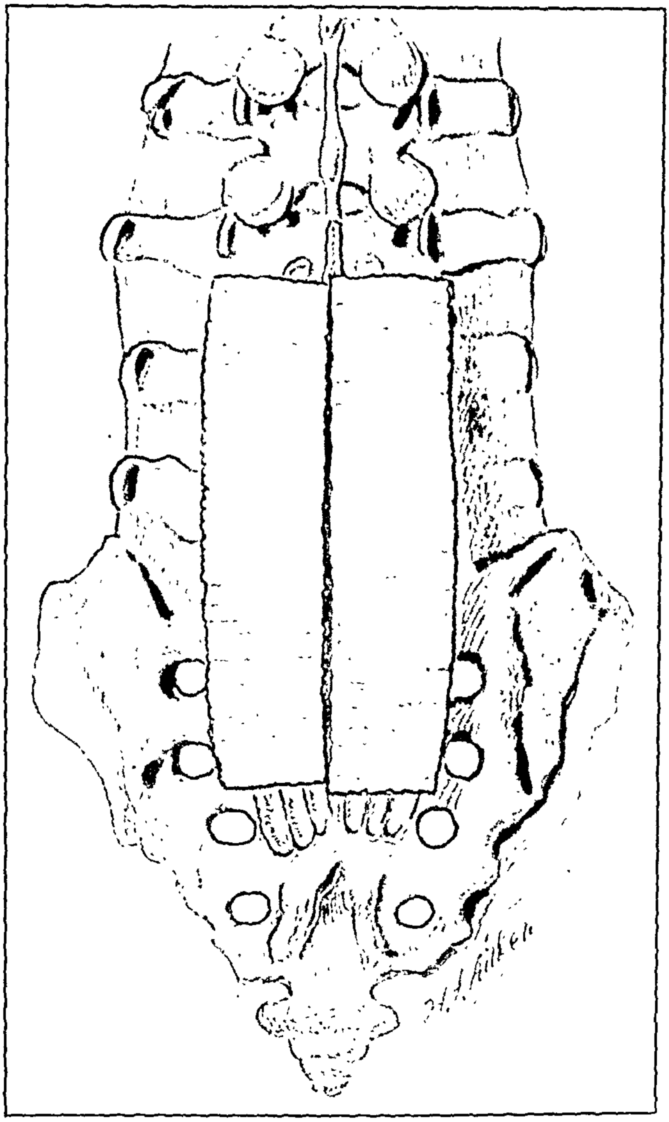

FIG. 8

Spine fusion, showing broad tibial grafts in place.

If the lumbar muscles are heavy, they are cut half an inch from their attachment on the sacrum in order to avoid undue pressure during retraction.

The spinous processes are cut off at their base, removed, and placed in salt solution. Care is taken to cut the third vertebra in a slanting direction to avoid a prominence that would become an area of tenderness.

Heavy chip grafts are turned up and down from each lamina. A special instrument is used for this purpose.

With the same instrument, heavy grafts are turned up from the sacrum. It is to be noted that, when actual slipping forward of the fifth lumbar vertebra has occurred, care must be taken to make the union between the laminae and the sacrum especially secure. If the laminae are mobile and cannot be successfully fused, they should be removed and included in the bridge of bone established at the base of the laminae.

The spinous processes are completely denuded of fascia and, in the case of younger persons, of cartilage attachments. They are then cut into fine pieces and carefully packed over the chipped grafts in the spine bed.

One or both tibiae are opened and osteoperiosteal grafts, together with numerous small slivers of cortical bone, are removed. The cortical

chips are first pressed over the grafts already in place, and then the broad tibial grafts are placed side by side, so that the final layer of grafts is about two inches in width and at least one inch in thickness at the lumbosacral junction. (See Figures 6, 7, and 8.)

The periosteum, muscles, and fascia are sutured over the grafts, and the skin is closed.

Care is taken to leave the wound dry by squeezing out the blood clots. A small sandbag is incorporated into the scultetus bandage to exert pressure on the wound and grafts during the first twenty-four to forty-eight hours. The patient is placed on his face.

After-Care

The patient is recumbent in bed for four weeks. A plaster jacket or pelvic back brace is then applied and is worn for a varying period of time. The patient should be ambulatory six weeks after the operation, and all support should be discarded within six months. The fusion should be solid in three months.

Comment

There was no operative shock in any case. There were no deaths. In one case, the wound became septic, partly as the result of excessive pressure from retractors as evidenced by sloughed muscle.

END RESULTS

At postoperative examination it was found, as a rule, that the patient with litigation pending continued to complain of symptoms longer than did the patient whose case had been uncomplicated. The only postoperative difficulty encountered in these cases has been pain in the coccyx, a symptom that is undoubtedly due to the more erect posture. It is, however, only transitory and disappears as soon as the flexibility above the fusion returns.

Thirty-three of the thirty-five patients were examined after a period ranging from one to five years. In the other two cases fusion had been done only five and six months previous to examination. The following table shows the approximate periods of follow-up:

5 months	1 case
6 months	1 case
1 year	12 cases
1½ years	2 cases
2 years	3 cases
2½ years	3 cases
3 years	3 cases
3½ years	1 case
4 years	5 cases
5 years	4 cases

Excellent results—that is, complete relief from symptoms—have been obtained in twenty-nine cases. Both clinically and by roentgenographic examination, the fusion has been demonstrated to be solid. The

patients have returned to their various occupations: several do heavy work; others are clerking; and one is a superintendent in a hospital. Two patients have borne children, and the deliveries have been normal and without difficulty.

One patient has relief from symptoms, but experiences a peculiar sensation in the back. This was a case in which the graft had to bridge over a defective lamina that was cartilaginous and separated. (The writer now removes such laminae at the time of operation.) The patient is doing heavy work and there is every indication that the final outcome will be satisfactory.

The patient upon whom the spine fusion was performed only six months ago has no symptoms at the present time, and the fixation is solid as evidenced in the roentgenogram. The eventual outcome should be satisfactory. It is likewise expected that the patient who was treated operatively five months ago will obtain an excellent result.

In the three remaining cases, symptoms have persisted after fusion, and the roentgenograms do not show solid fixation.

CONCLUSIONS

From the satisfactory results obtained by operative fusion of the lumbosacral region in a series of thirty-five cases, it would seem that this procedure has a definite place in the treatment of low-back pain, when conservative measures are of no avail and when the roentgenogram demonstrates pathology or structural changes consistent with the clinical findings.

Operative fusion of the spine, to be effective in abolishing back pain, must insure absolute obliteration of all motion at the lumbosacral junction. In cases where fusion of the spine has failed to give relief, the fixation has been found, both clinically and by roentgenographic examination, to be incomplete. By the use of the operative technique described by the writer, elimination of all motion is certain.

In the diagnosis of low-back pain, more attention should be directed to the bony structure in the lumbar region and particularly to the posturally defective back. In the presence of atypical structures, trauma becomes at the most only an aggravating factor in the causation of pain. The significance of defective structures is to be especially considered in the care of industrial injuries.

Our understanding of the structural abnormalities that may underlie back pain now makes it possible to single out the spine that may be a potential source of disturbance. As a result, fusion may be carried out without subjecting the patient to long-drawn-out conservative treatment. Also, from stereoscopic studies of the lumbosacral region, it is possible to classify laborers as to physical fitness for heavy work.

REFERENCE

MITCHELL, G. A. G.: The Lumbosacral Junction. J. Bone and Joint Surg., XVI, 233, Apr. 1934.

A METHOD OF DEALING WITH CHRONIC OSTEOMYELITIS BY SAUCERIZATION FOLLOWED BY SKIN GRAFTING

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The problem of applying Thiersch grafts to cavities and recesses has been successfully solved by Esser and Gillies in their plastic work. Esser devised the plan of applying the grafts on a mold of Stent's dental composition which exactly fitted the cavities to be grafted.

The idea was conceived that this method might well be applied in promoting the rapid epithelialization and healing of bone cavities left after radical operative treatment of chronic osteomyelitis. Prior to the adoption of this method some eight years ago, these cavities had been treated by packing with sterile gauze in the ordinary way, and it was noted that the granulations grew much faster from the peripheral parts of the cavities than from their depths, which often resulted in the formation of small deep-lying saccules connected by a narrow track with the superficial surface of the granulation tissue. These saccules were responsible for the persistence of multiple points of discharge on the surface of the granulation tissue and failure of epithelialization at these points.

The method to be described obviates this disadvantage and promotes really rapid epithelialization.

DESCRIPTION OF THE METHOD

First Stage: Saucerization of the Diseased Area

A tourniquet is applied, as this greatly facilitates the operation by improving the field of vision.

An incision is made to expose the area of bone to be dealt with. This incision embraces all sinus-bearing areas in the immediate vicinity, and such areas are excised.

Sufficient bone is then removed to expose the chronic osteomyelitic cavities which may contain sequestra. In the performance of this early step in the operation, either the periosteum should not be reflected at all, prior to the removal of the outer layer of bone with the chisel, or such reflection should be extended no more than is absolutely necessary, as the outer layers of the long bones receive their blood supply from the periosteum and the removal of the latter will result in the sequestration in flakes of the superficial layer of bone along the border of the cavity left after saucerization.

All sequestra are removed and the diseased area of bone is thoroughly eradicated until the cavity so formed is surrounded by relatively smooth and healthy involucrum. In performing this eradication of the diseased areas of bone, it is advantageous, whenever possible, so to shape the cavity that in transverse section it resembles a funnel or saucer with the mouth wider than the floor, and in longitudinal section it has at its proximal or distal extremity, or at both, a considerable overhang formed by the superficial layer of the excavated bone. The recesses thus formed will provide an efficient natural means of retention for the stent mold which is to be applied at a later stage in the treatment.

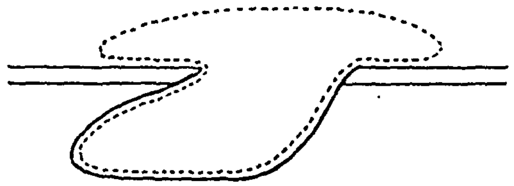

FIG. 1-A

Cavity requiring only a single stent mold for grafting purposes.

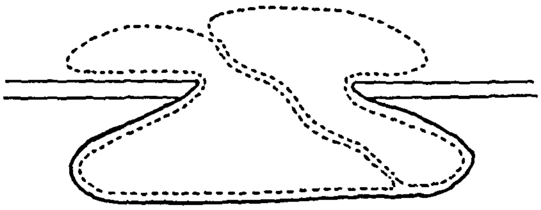

FIG. 1-B

Cavity requiring the insertion of two stent molds for grafting purposes.

Providing an overhang of bone in this manner may also have anatomical advantages; for example, when diseased bone must be removed from the diaphysis of the upper end of the tibia close to the epiphysis, this can be accomplished without disturbing the tibial tuberosity and its tendinous attachment. It is important that all the diseased bone, or as much as is possible, should be removed, for such diseased foci as remain will form nuclei for the persistence of infection and will tend to interfere with complete and permanent epithelialization.

The margins of the skin incision are sutured to the periosteum and deep fascia along the border of the cavity left after saucerization. The cavity is then packed with sterile gauze. Fairly voluminous sterile dressings of gauze and wool are then applied and the limb is fixed on a simple splint. Two days later, the dressings and gauze packings are removed under nitrous oxide anaesthesia and the cavity is washed out with warm sterile saline solution and repacked. This procedure is repeated every two days for six days; anaesthesia is usually found to be unnecessary after the sixth day. The wound is now dressed daily and washed out with sterile saline solution. When the bone cavity is completely lined by healthy looking granulation tissue, the second stage in this operative treatment—the Thiersch grafting of the cavity—is undertaken.

Second Stage: Skin-Grafting of the Cavity

Stent's dental composition is sterilized by immersion in a watery solution of mercuric biniodide. The cavity to be grafted and the area from which the grafts are to be taken are prepared and draped in the usual manner. As much dental composition as is required to fill the cavity to

Fig. 2-A: Case 1. Wound prior to insertion of Stent's composition to make the mold.
Fig. 2-B: Stent mold covered with Thiersch grafts.
Fig. 2-C: Mold, bearing grafts, held in position in the wound.
Fig. 2-D: Mold held in position by means of gauze dressing and adhesive strapping.
Fig. 2-E: Two months after grafting, wound completely epithelialized.

FIG. 2-A

FIG. 2-B

FIG. 2-C

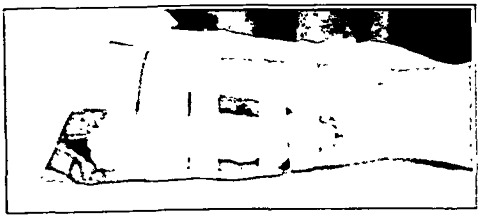

FIG. 2-D

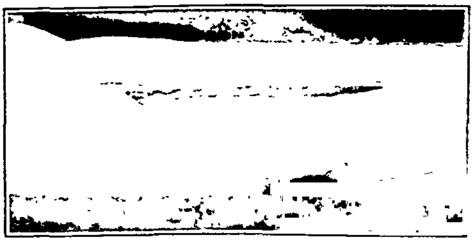

FIG. 2-E

be grafted is now rendered malleable by immersion in thoroughly hot water, and the malleable mass is inserted into the cavity and, by gentle pressure of the fingers, is made to apply itself to all parts of the cavity and allowed to set hard. In this way an accurate mold of the cavity is obtained.

In those instances where both proximal and distal recesses, with an overhang of superficial bone, have been made, it is obvious that it will be necessary to use two separate molds of dental composition, each representing a portion of the cavity to be grafted, as the insertion or withdrawal of one complete mold when set hard would be impossible. (See Figure 1-B.) Sometimes the shape of the cavity, apart from the presence of both distal and proximal recesses, determines the necessity for using two separate molds, for, although the insertion of one complete mold is possible, it cannot be done without disturbing the grafts which it is to bear.

Those areas of the mold, or molds, which represent an accurate cast of the surface of the cavity are now covered with Thiersch skin grafts, their deep surfaces uppermost, and the mold, or molds, now bearing the skin grafts, are reinserted into the cavity. In order that the Thiersch

FIG. 3-A

FIG. 3-B

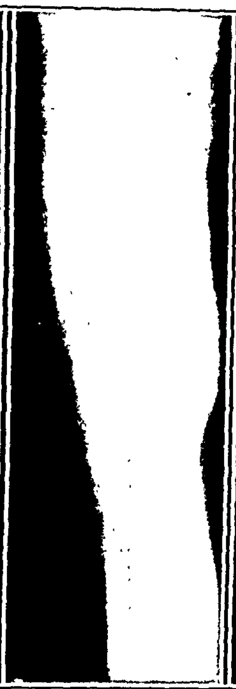

FIG. 3-C

FIG. 3-D

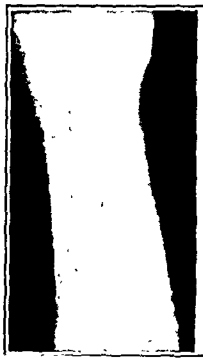

FIG. 3-E

FIG. 3-F

FIG. 3-G

Fig. 3-A: Case 2. Cavity in upper part of tibia completely epithelialized six weeks after grafting. Cavity in lower part of tibia ready for grafting.

Fig. 3-B: Same as Fig. 3-A. Lower cavity almost healed, three weeks after grafting.

Fig. 3-C: Roentgenogram of tibia before saucerization.

Fig. 3-D: Roentgenogram of tibia after saucerization.

Fig. 3-E: Roentgenogram of lower end of tibia before saucerization.

Fig. 3-F: Roentgenogram of lower end of tibia after saucerization.

Fig. 3-G: Lower cavity, completely epithelialized, five weeks after grafting.

grafts may be kept in firm contact with the granulations covering the walls of the cavity, it is necessary to maintain gentle but steady pressure on the mold after it has been inserted. This can be done quite easily by means of adhesive strapping. However, as the external surface of the mold is often concave, it is frequently desirable to apply a second piece of dental composition, external to the mold proper, in order to facilitate the application of pressure through the strapping.

Sterile dressings are applied and the limb may be bandaged to a simple splint. The mold is allowed to remain in position for ten days, during which time the limb is not disturbed at all; at the end of this time, the mold is removed. The major portion of the Thiersch grafts will be found

to be living and attached to the granulations around the walls of the cavity.

The cavity is now dressed daily. Warm normal saline solution is dropped in and gently blotted away with gauze. No packing is inserted into the cavity, but a light gauze dressing is applied across it as a shield. Epithelialization now proceeds rapidly and in the space of four to ten weeks, depending on the size of the cavity grafted, the patient's own individual potentialities toward healing, and other factors, the cavity is lined with a fairly thick layer of skin. As might be expected, this layer of skin is at first closely adherent to the bone, but, with the passage of time, a deposition of a certain amount of subcutaneous tissue appears to take place beneath the newly formed epithelium.

Fig. 4-A

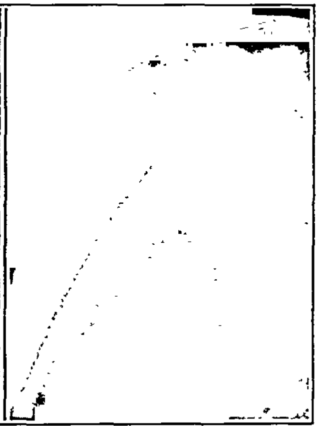

Fig. 4-B

Fig. 4-A: Case 3. Roentgenogram of right humerus before operation, showing extensive disease and sequestrum formation.

Fig. 4-B: After saucerization.

Fig. 4-C: Cavity completely epithelialized, ten weeks after grafting.

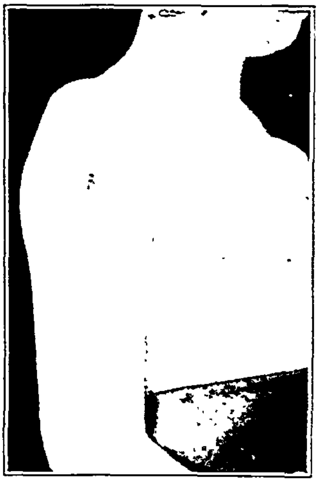

Fig. 4-C

The following cases have been observed for some considerable time since operation and in none of the cases have the epithelialized areas broken down to form fresh sinuses.

CASE REPORTS

Case 1. A male, aged thirty, was admitted from another hospital where an operation had been performed for acute osteomyelitis of the right femur. Since operation, a large gaping wound, connected with a cavity in the right femur, had persisted and refused to heal for nine months.

No further operation was required on the femur itself. The large gaping wound was thoroughly cleaned and Thiersch grafts were applied over a mold of Stent's dental composition. Healing occurred in two months, during which the whole area of the wound became completely epithelialized. (See Figures 2-A, 2-B, 2-C, 2-D, and 2-E.)

Case 2. A male, aged thirteen, had had chronic osteomyelitis of the left tibia with six discharging sinuses for four years. There had been occasional acute exacerbations of the condition, and operative interference had been necessary in one instance.

When admitted to the Royal Sea-Bathing Hospital, the patient had four discharging sinuses over the anterior aspect of the upper half of the left tibia and two over the lower

FIG. 5-A FIG. 5-B

Fig. 5-A: Case 4. Roentgenogram of left shoulder joint, showing extent of disease and obliteration of joint space.

Fig. 5-B: After saucerization.

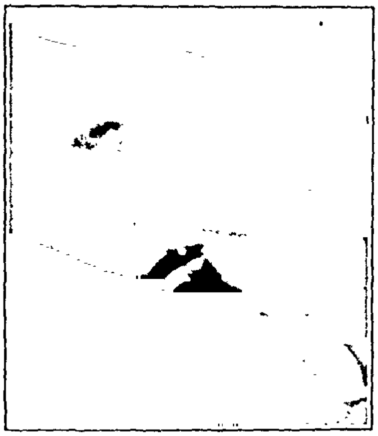

FIG. 5-C

Fig. 5-C: Cavity completely healed, twelve weeks after grafting.

third near the ankle joint. Roentgenographic examination revealed a large area of chronic osteomyelitis, with cavities, occupying the upper half of the tibia and a smaller area in the lower third.

The upper half of the left tibia was laid open, the sequestra were removed, and saucerization was performed. Care was taken not to prolong the saucerization too much proximally for fear of damaging the upper tibial epiphysis. Two weeks later, skin grafting of the saucerized area was done.

Ten days after grafting, the stent mold was removed, and, six weeks after grafting, the cavity had become completely epithelialized.

The cavity in the lower third of the tibia was dealt with in a similar manner, and complete epithelialization occurred five weeks after the skin grafting. (See Figures 3-A, 3-B, 3-C, 3-D, 3-E, 3-F, and 3-G.)

CASE 3. A male, aged sixteen, had had acute osteomyelitis of the right humerus four months prior to admission to the Royal Sea-Bathing Hospital. Two operations had been performed during the acute stage, and the right arm and shoulder had been put up in a plaster cast.

On admission, examination revealed extensive disease of the upper half of the right humerus with sequestrum formation, and three discharging sinuses. The shoulder joint was not involved.

Sequestrectomy and extensive saucerization of the upper half of the right humerus were performed and large sequestra were removed. Two weeks later, skin grafting of the cavity was done. Ten days after grafting, the stent mold was removed.

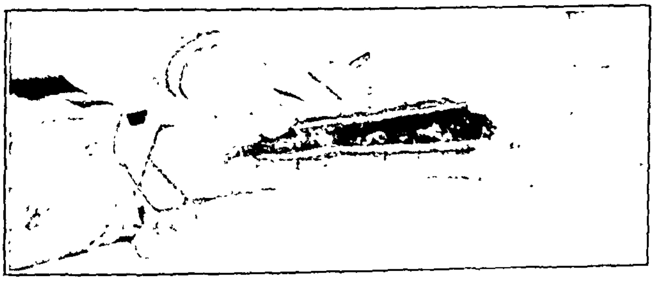

FIG. 6-A

FIG. 6-B

Eight weeks after grafting, the operative site was almost completely epithelialized, except for two small areas. Ten weeks after grafting, the cavity was completely epithelialized. (See Figures 4-A, 4-B, and 4-C.)

CASE 4. A male, aged twenty-three, had had acute osteomyelitis of the left shoulder joint six months prior to admission to the Royal Sea-Bathing Hospital. The shoulder joint had drained at that time. A discharging sinus had persisted until admission.

On admission there was marked limitation of movement at the left shoulder joint with two discharging sinuses, one on the anterior aspect and one on the inferior aspect of the joint.

Roentgenographic examination revealed obliteration of the joint space and the normal joint markings, with destruction of the head of the humerus. Conservative treatment was tried for some time, with the arm and shoulder joint fixed on a splint. However, as the sinuses persisted and acute exacerbations with abscess formations occurred, radical operative treatment was finally resorted to.

The shoulder joint was opened, débris and the remains of the humeral head were removed, and diseased bone was excised from the upper end of the humerus and from the acetabulum. The skin edges were sewed to deep fascia and muscle, and the cavity was packed in the usual way. Three weeks later, skin grafting of the cavity was done. Ten days after grafting, the stent mold was removed.

Six weeks after grafting, it was found that the grafts had taken well, but fairly large areas which had not yet be-

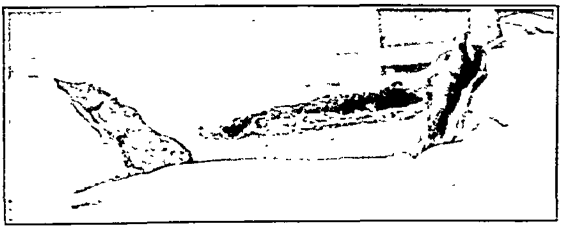

FIG. 6-C

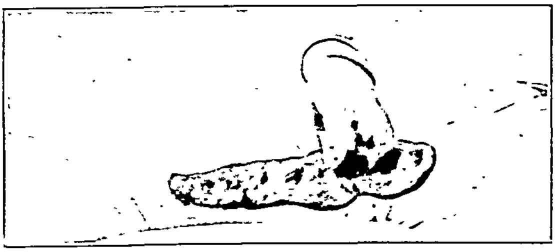

FIG. 6-D

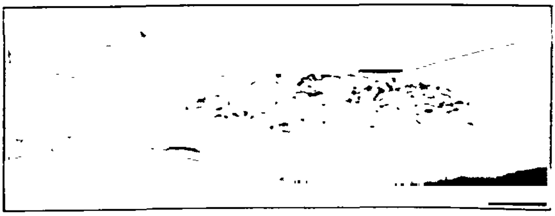

FIG. 6-E

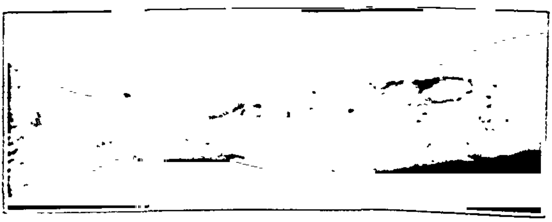

FIG. 6-F

Fig. 6-A: Case 6. End of first stage of operation. The diseased area of the tibia has been laid open; sequestra have been removed; and the bone has been saucerized. The skin edges have been sutured to deep fascia and periosteum.

Fig. 6-B: Cavity covered with healthy granulation tissue, ready to graft.

Fig. 6-C: Showing two stent molds ready for covering with grafts.

Fig. 6-D: Showing the two molds inserted into the cavity.

Fig. 6-E: Eight weeks after grafting, cavity almost completely epithelialized, except for a few small areas.

Fig. 6-F: Ten weeks after grafting, cavity completely epithelialized.

come epithelialized persisted in the cavity. Nine weeks after grafting, almost the whole of the cavity had epithelialized. Eleven weeks after grafting, a small sequestrum separated in the floor of the wound. Twelve weeks after grafting, complete epithelialization had taken place. (See Figures 5-A, 5-B, and 5-C.)

CASE 5. A male, aged twenty-three, had had chronic osteomyelitis of the left femur of two years' duration, with a persistent sinus which discharged a profuse amount of pus. On admission to the Hospital, roentgenographic examination revealed an osteomyelitic area in the lower third of the femur, with a cavity containing a fairly large sequestrum.

Saucerization, with sequestrectomy of the lower end of the femur, was performed and a large sequestrum was removed. Ten days later, skin grafting of the cavity was done. Ten days after grafting, the stent mold was removed.

Three weeks after grafting, the cavity was almost completely epithelialized; six weeks after grafting, there was only a small area in the deepest and lowest recess of the cavity which had not become epithelialized. Eight weeks after grafting, complete epithelialization had occurred.

CASE 6. A male, aged seventeen, had had chronic osteomyelitis of the left tibia of two years' duration, with multiple discharging sinuses.

FIG. 7-A

FIG. 7-B

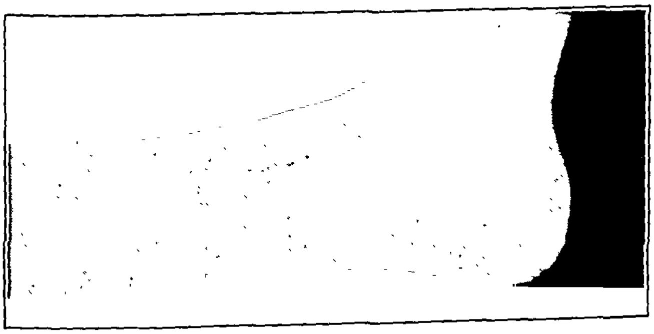

FIG. 7-C

Fig. 7-A: Case 7. Probe inserted into sinus in connection with diseased area in lower end of tibia.

Fig. 7-B: End of first stage of operative treatment. The skin edges have been sutured to periosteum and fascia.

Fig. 7-C: Four weeks after grafting, cavity completely epithelialized.

Fig. 7-D: Roentgenogram showing extent of cavity left after saucerization.

FIG. 7-D

On admission, roentgenograms revealed a chronic osteomyelitic process involving the upper three-fourths of the left tibia, with sequestrum formation. The knee and ankle joints were not involved. There were nine sinuses over the anteromedial aspect of the upper two-thirds of the left tibia, all of which discharged pus fairly profusely.

The large sinus-bearing area was excised, the upper two-thirds of the tibia was laid open and large sequestra were removed, the bone was then saucerized, and the skin edges were sutured to periosteum and deep fascia around the large cavity. Four weeks later, the cavity was lined with fairly healthy granulation tissue, and skin grafting was performed. Because of the shape of the cavity, two stent molds were used. Ten days after grafting, the stent molds were removed.

Four weeks after grafting, there were some areas where epithelialization had taken place, but large unepithelialized areas persisted. Eight weeks after skin grafting, the unepithelialized areas were much smaller, and two weeks later there were only a few small areas which remained unepithelialized. Thirteen weeks after skin grafting, complete epithelialization had taken place. (See Figures 6-A, 6-B, 6-C, 6-D, 6-E, and 6-F.)

Case 7. A male, aged twelve, had had chronic osteomyelitis of the lower end of the left tibia of three years' duration. During this time, acute exacerbations had occurred, with a persistent discharging sinus.

Roentgenographic examination revealed an osteomyelitic area and a cavity in the lower third of the left tibia.

The sinus was traced into the cavity in the lower third of the tibia. The cavity was laid open, the débris and some small sequestra were removed, and the diseased area of bone was saucerized. The skin was sutured to the margins of the cavity. Skin grafting of the cavity was done two weeks later. Ten days after grafting, the stent mold was removed.

Four weeks after grafting, the cavity had become completely epithelialized. (See Figures 7-A, 7-B, 7-C, and 7-D.)

Case 8. A male, aged twenty-one, had had chronic osteomyelitis of the lower third of the left femur of four years' duration. Several acute exacerbations had occurred during this time, and there had been four persistent discharging sinuses.

On admission to the Royal Sea-Bathing Hospital, roentgenograms revealed a chronic osteomyelitic process in the lower third of the femur, with sequestrum formation.

Physical examination disclosed almost complete fixation of the knee joint in 50 degrees of flexion. This deformity was corrected completely by means of a hinged knee splint with continuous spring extension, and a considerable degree of movement was restored to the knee joint.

Sequestrectomy and saucerization of the lower third of the femur were performed. Four weeks later, skin grafting of the cavity was done. Ten days after grafting, the stent mold was removed.

Seven weeks after grafting, the cavity had become almost completely epithelialized except for a very small area in its lowest recess. Nine weeks after grafting, the cavity was completely epithelialized. Seen as an out-patient fourteen months after operation, the patient was working as a motor mechanic, and the cavity had remained soundly healed.

COMMENTS

In presenting this method of dealing with the bone cavities left after radical operation for chronic osteomyelitis, no claims are made that the end results are superior to those obtained by the Orr method, the excellent results of which have been described by Kulowski. However, it has the advantage of promoting much speedier epithelialization and healing, and there is no unpleasant odor associated with it.

It has occurred to us that this method might, with advantage, be applied during Baer's maggot treatment at that stage when the wounds are filled with healthy, red granulations, when the reaction of the wound discharges is alkaline, and when pathogenic bacteria are few in number.

There is definite evidence that the deep but completely epithelialized cavities which result from this method of treatment tend to diminish in size with the passage of years.

NOTE: "Stent's composition" is a dental-impression composition extensively used in Great Britain, but any standard dental-impression composition will serve the purpose equally well.

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FRACTURES OF THE FOREARM REDUCED BY DIRECT LEVERAGE *

BY J. E. M. THOMSON, M.D., F.A.C.S., LINCOLN, NEBRASKA

The method referred to as direct leverage has been employed by the author for the reduction of fractures in almost all of the long bones of the skeleton. Reports of this work have been read before various organizations and have appeared in the literature from time to time. Fifteen years of experience with this method has proved that it is particularly adapted to the reduction of a rather definite group of fractures of the forearm.

TYPE OF CASE

For the reduction of fractures of the forearm, direct leverage is indicated and recommended under the following circumstances:

1. When the ordinary methods of manipulation and traction have failed to bring satisfactory reduction of the fractured fragments.
2. In all fractures in which open operation is indicated, with perhaps the exception of those in which the fragments are severely comminuted or in compound fractures.
3. When one bone, either the radius or the ulna, is fractured and difficult to reduce.
4. When both bones are fractured and there is a greenstick fracture of one and overriding of the fragments of the other. In such a case, direct leverage of the overriding fragments will usually reduce this fracture without danger of completing the greenstick.
5. In fractures of both bones in which one fracture is reduced and there is overriding in the other. Direct leverage to the overriding fragments can usually be applied without loss of position in the other reduced fracture.
6. When, with the help of traction, full length of the fragments can be obtained, but apposition and alignment are difficult. The application of direct-leverage technique to the fragments will usually bring the desired anatomical position.

TECHNIQUE

This method requires the simplest type of operative procedure and the minimum amount of risk. It is relatively no more dangerous than the introduction of a local anaesthetic. It is often performed under local anaesthesia. A very simple set-up is usually all that is necessary,—a tray, a gown, a pair of gloves, a scalpel, a lever, and a few dressings. Any type of fluoroscope may be used. In the author's Clinic the head type of

* Presented at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 7, 1935.

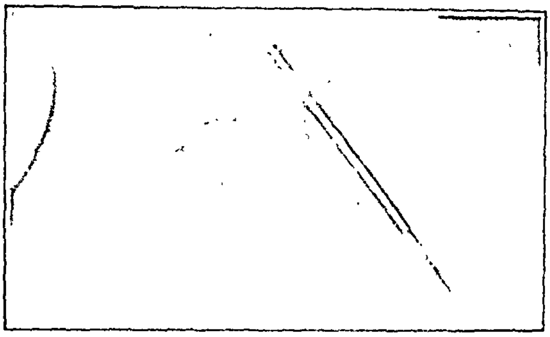

FIG. 1
Type of lever used.

fluoroscope is used, while at the hospitals the fluoroscopic table is employed. The fact that the arm can be turned from the anterior-posterior to the lateral position so easily before the fluoroscope has contributed a great deal to the adaptability of this technique to forearm fractures.

After the operator's eyes have become accustomed to the darkness, the patient's arm is held by assistants before the fluoroscope. The conventional rules of aseptic operative technique are followed by the operator and his assistants throughout the procedure. The lever is usually introduced through a stab wound on the dorsal side of the forearm over the site of fracture. The type of lever used is an ordinary dental chisel or straight dental instrument with a blunt point. The ends of certain dental instruments are often cut off for this purpose. Under the guidance of the fluoroscope, the lever is inserted between the fragments, so that the end of the lever impinges on one fragment and the shaft is against the other fragment. It is usually necessary to introduce the lever between the overriding fragments at a considerable angle. After the impingement is made, the lever is carried through an arc, the shaft bringing pressure in one direction on one fragment and the end of the lever bringing pressure in the opposite direction on the other fragment. In this manner, the overriding of the fragments is completely overcome. As the lever continues its course through the arc, one fragment is lifted while the other is depressed; apposition and alignment are obtained as the fragments glide and impinge into position when the lever is removed. Anterior-posterior plaster-of-Paris molded splints are usually applied, extending from the base of the fingers to the upper arm with the hand in dorsiflexion, and the arm in supination or midsupination, depending upon the type and position of the fracture. The forearm is flexed on the arm at an angle of 90 degrees. Padding is seldom used except in the form of light

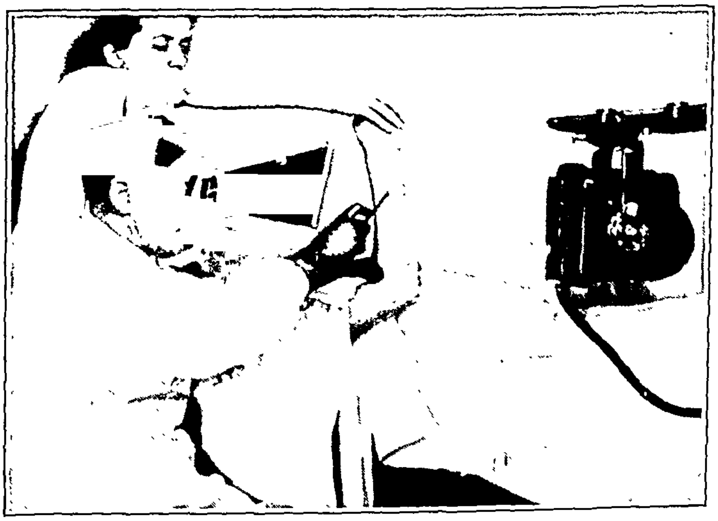

FIG. 2
Direct leverage as performed with a head fluoroscope and shock-proof x-ray unit.

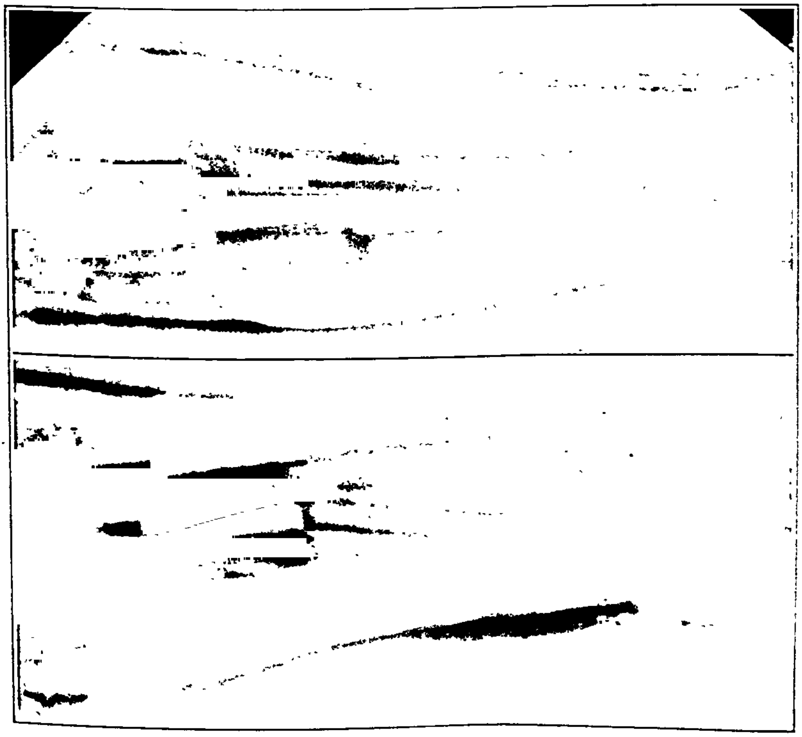

FIG. 3-A FIG. 3-B

Anteroposterior and lateral x-rays of radius and ulna. Both bones were fractured and there was overriding at different levels. The fracture of the radius has been reduced, but the fragments of the ulna remain overriding and displaced.

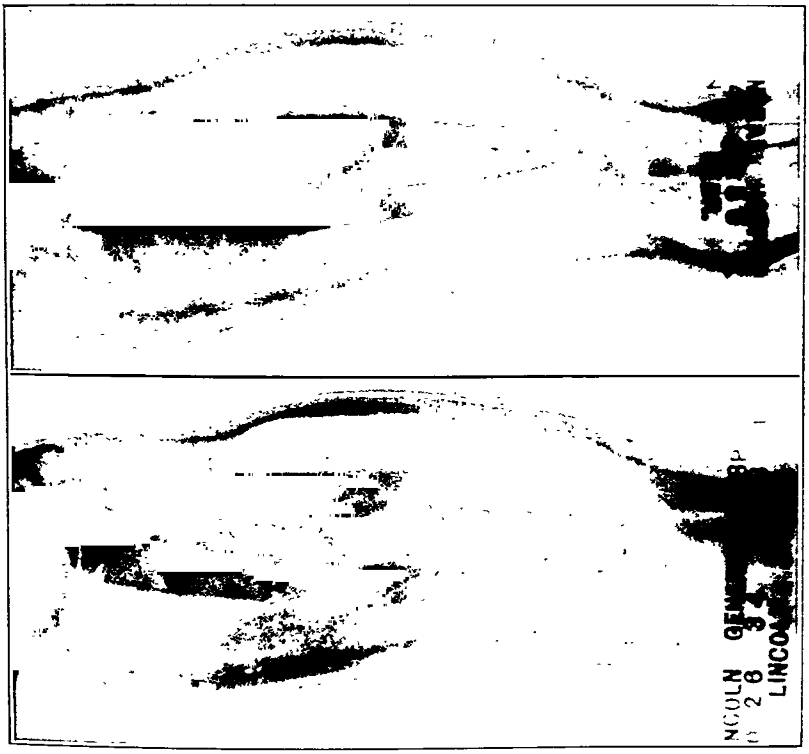

FIG. 4-A FIG. 4-B

Lateral and anteroposterior x-rays showing reduction after direct leverage through a window in the cast.

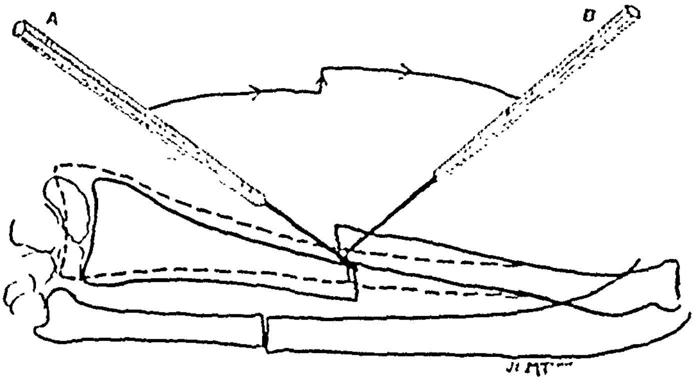

FIG. 5

Drawing showing a fracture of the radius and ulna at different levels: the fracture of the ulna is reduced; the fragments of the radius are overriding after attempted reduction. *A* represents the position of the lever at the beginning of reduction. The end of the lever is against the lower fragment, and the shaft of the lever is against the upper fragment. The lever is carried through the arc, as indicated by the arrows, thus overcoming the overriding and depressing and lifting the upper and lower fragments into apposition. The dotted line represents the reduced fracture. *B* shows the position of the lever after it has been carried through the arc necessary to bring about reduction.

felt pads about the elbow and the upper and lower ends of the splint.

Direct leverage has followed the use of Kirschner-wire traction and countertraction in the olecranon and lower forearm when there is difficulty in attaining adequate apposition and alignment. Occasionally, direct leverage has been performed through a window in the cast over the site of the deformity in cases in which the fracture was apparently well reduced and splinted, but in which a subsequent roentgenographic check-up showed an overriding of the fragments in one of the fractures. In a few instances, it has been necessary to leave the lever embedded between the fragments in order to insure apposition. When this is necessary, the lever is embedded in the plaster-of-Paris cast and removed in a week or ten days without danger of losing the position.

In a few instances where a fluoroscope was not available, a small incision was made over the fragments and the leverage procedure was followed with the fragments in sight, without extensive exposure or injury to soft tissues or bone.

RESULTS

This report is based upon a study of 362 consecutive patients with fractures of the forearm, treated by the author during the past fifteen years. Incomplete records and insufficient follow-up data made it necessary to omit eighty-five of these patients from this study. Among these were seven who had had fractures which had been successfully reduced by direct leverage, without complications, but, due to the fact that they had left the author's care and had returned to distant homes within the first few weeks, they could not be contacted for follow-up data. However, it may be assumed that they made satisfactory recoveries within the expected time, for in the author's experience any fracture patient who has trouble or complications of any kind will return with the bad tidings from far or near and spread the sad news to all who will listen.

In the 277 remaining patients, counting those who had fractures of both arms and those in whom both the radius and ulna of one arm were

fractured, there was a grand total of 377 fractures of the forearm. The fact that 110 of these patients, or practically 40 per cent., had had unsuccessful attempts at reduction from a few days to several months prior to being referred to the author seems of unusual interest. In other words, 40 per cent. of the patients in this series presented more than the ordinary problems in the reduction of the fractures. Eighty-six per cent. of the fractures in the entire series requiring operative procedures—open operation or direct leverage—came within this group. In 377 fractures of the radius and ulna, direct leverage was used in forty-six instances. It was used about an equal number of times in fractures of the lower and middle thirds of the radius and ulna and twice in fractures of the upper third of the ulna.

A careful study of the end results revealed the fact that in cases of fractures reduced by direct leverage the period of disability was no longer than in those in which simple closed methods of reduction were employed. Also, in the few cases in which the lever remained embedded in the cast for a week or ten days, the period of disability was no longer than that of the group in which simple closed methods of manipulation were used. However, in the fractures of the forearm requiring extensive open operative procedures, the period of disability was very much increased and often doubled, and the amount of partial permanent disability was much greater than in those fractures reduced by direct leverage and simple methods. In every instance in which direct leverage was used, not only were good apposition and alignment and an average period of disability obtained, but there were excellent functional results. Not a single infection resulted in the entire series.

CONCLUSION

Those who discussed the author's early reports of this method recognized its merit, although they drew attention to the dangers of introducing a foreign body between the fragments,—the possibility of infection, the promotion of delayed union, and the peril of injury to the tender soft-tissue structures.

This review of 377 fractures of the forearm shows that there was a certain definite group of these fractures (forty-six) in which reduction could not be obtained by ordinary methods, and in which rather extensive open operative procedures would usually be indicated. However, these fractures were reduced by the technique of direct leverage, with results equal to those obtained in non-problem fractures in which simple methods of reduction were adequate.

AMPUTATION FOR SARCOMA OF THE NECK OF THE FEMUR BY THE INTERINNOMINO-ABDOMINAL METHOD

BY R. R. FITZGERALD, F.R.C.S. (ENG.), MONTREAL, CANADA

From the Children's Memorial Hospital, Montreal

In 1891, Billroth made the first attempt to remove the whole lower extremity, together with the innominate bone. The case was not published, but, when Savariaud wrote his article on the subject in 1902, Billroth was given the credit for being the first to carry out the procedure. This operation has not often been practised, but, in the years that have intervened since Billroth's venture, a number of surgeons have had occasion to attempt it, and in 1935 Gordon-Taylor and Wiles were able to assemble from the literature data on fifty authentic cases. To this number, they added five cases of their own, bringing the total to fifty-five. Since the appearance of that paper, Gordon-Taylor has added another successful (unpublished) case.

In the history of the evolution of the operation, the difficulties involved have been surmounted one by one.

Incisions to give adequate flaps have been suggested by Jaboulay, Girard, Bardenheuer, Salistschef, and Savariaud. That proposed by Girard has been the most useful, and is now always employed unless local conditions demand some modification.

Hemostasis was secured in some of the early cases by the Momburg tourniquet, but of late the ligation of the external iliac vessels has been practised. The common iliac artery cannot be tied without endangering the flaps.

Spinal anaesthesia was employed by Gordon-Taylor and Wiles in conjunction with ether. In the author's case, spinal anaesthesia alone was used.

The prevention of shock, by lowering the head of the table, by the administration of ephedrine hypodermically when the blood pressure falls, by the injection of the large nerves with novocain solution before they are divided, and by the transfusion of blood at the close of the operation, has finally made this seemingly forbidding procedure relatively safe. Although Gordon-Taylor and Wiles found a mortality of 56.4 per cent. in the fifty-five cases that they collected, they were able to report that four out of five of their own patients had survived.

The operation has been used in attempts to cure primary sarcoma of the bone or of the soft tissues, chondrosarcoma, tuberculosis, osteoclastoma, myxosarcoma, and infective osteomyelitis. Geschickter and Copeland have drawn attention to the fact that, in cases of tumor in which bone formation is a pronounced feature, amputation has saved a considerable number of patients (26 per cent. of their series).

The operation may be carried out as a single-stage procedure, or it

may be done in two stages,—that is, disarticulation at the hip followed later by removal of the innominate bone.

CASE REPORT

A colored boy, thirteen years old, was admitted to the Children's Memorial Hospital on April 17, 1935. He had had no previous illness except mild bronchitis in infancy. Five weeks before admission he had fallen at play, striking his right knee on the ground. This injury had been followed by pain in the right hip, and a limp had developed. The limp had gradually grown worse, and the pain had increased in severity, becoming constant throughout the day and disturbing his sleep in the early mornings. His appetite had failed.

On examination, there was found wasting of the whole extremity. The right thigh measured one inch less in circumference than the left, and the right calf one-half an inch less than the left. The hip was flexed, abducted, and rotated outward. The range of movement was restricted by pain. There was tenderness over the upper end of the femoral shaft. Roentgenographic examination showed a destructive lesion involving the anterior portion of the femoral neck and the upper part of the shaft. On May 14, under ether anaesthesia, a fragment of a soft vascular mass attached to the femoral neck was removed for diagnosis through an anterior vertical incision. Histological study showed that the tumor was an osteoblastic osteogenic sarcoma, with extensive bone formation.

Amputation was accordingly advised, but was declined by the parents. In a few days, a swelling became visible at the site of the incision, and a course of seven injections of Coley's fluid was given without evident effect. The pain gradually became unbear-

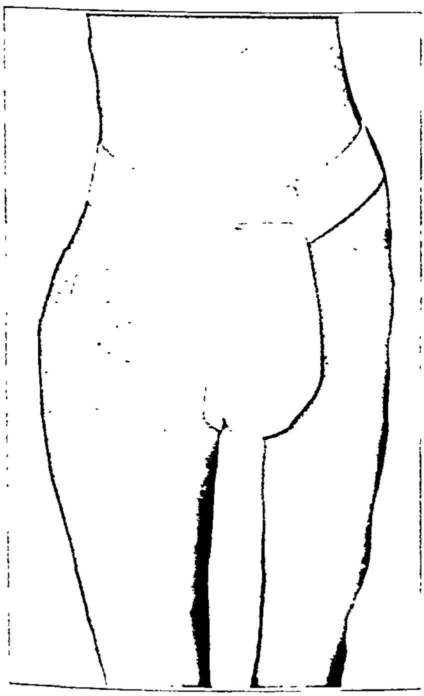

Fig. 1

Photograph before operation, showing tumor of the thigh and biopsy wound beginning to break down at its center

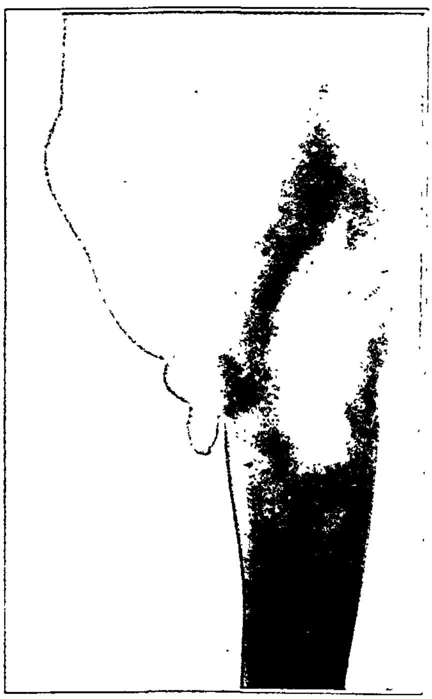

Fig. 2

Patient on discharge, twenty-two days after operation.

able, the exploratory wound opened spontaneously, and a hemorrhagic discharge appeared. At this stage (Fig. 1) permission for amputation was given. A second roentgenogram, taken immediately before the operation (Fig. 5), revealed rapid advance in the size of the tumor, increased destruction of the femoral shaft, and extensive bone formation.

Operation

On June 18, 1935, under novocain anaesthesia, an amputation of the right limb was performed by the interinnomino-abdominal method. The preoperative medication was as follows: One hour before operation, one grain of nembutal was given by mouth; one-half an hour before operation, a second dose of one grain of nembutal was given orally, together with one-eighth of a grain of morphine and one three-hundredths of a grain of atropin hypodermically. For the anaesthetic, 150 milligrams of crystalline novocain was dissolved in five cubic centimeters of spinal fluid through lumbar puncture.

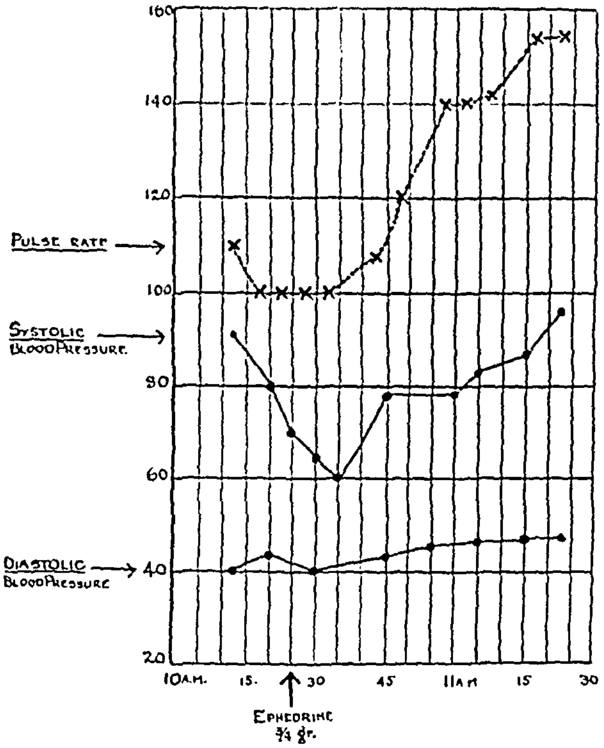

FIG. 3

Chart showing pulse and blood pressure during interinnomino-abdominal amputation.

The head of the table was lowered, and the patient was placed on his back and rolled over slightly toward the sound side, with sand pillows behind the right shoulder and hip. The left leg was tied to the table to prevent sliding.

The incision, as proposed by Girard, began at the right posterior-superior iliac spine, followed the iliac crest and the inguinal ligament to the pubic spine, and then turned downward at the perineoscrotal junction to the medial surface of the thigh. The muscles were detached from the iliac crest, and the iliac fossa was palpated for intrapelvic extension of the growth. None was found. The inguinal ligament was detached from the anterior-superior spine and the external iliac artery was ligated with silk. The femoral nerve was injected with novocain and divided. The external iliac vein was then ligated with catgut; the interval between the ligation of the artery and of the vein permitted most of the blood in the extremity to return to the trunk. The spermatic cord was retracted medially, and the origins of the rectus abdominis and pyramidalis muscles were separated from the pubic crest. The pubic symphysis was cut through with a knife. The patient was then turned completely onto his left side. A vertical incision was made, beginning just behind the midpoint of the iliac crest and extending down to the gluteal fold and around the back of the thigh to meet the medial end of the first incision. The iliac bone was exposed; the superior gluteal artery was tied; and the bone was cut through from the crest to the sacrosciatic notch with a Gigli saw. The obturator vessels were then ligated and divided inside the pelvis. The obturator and sciatic nerves were injected with novocain solution and divided. In successive stages, the piriformis was divided; the inferior gluteal vessels were tied and cut; the levator ani, the psoas muscle, and the sacrotuberous ligament were divided; and the limb was removed from the body. The peritoneum was

FIG. 4

Roentgenogram on admission, showing destructive lesion involving the neck of the right femur.

FIG. 5

Roentgenogram just before operation, showing increase in bone destruction, bone formation, and size of the growth.

FIG. 6

Roentgenogram of the pelvis after interinnomino-abdominal amputation.

not opened. The edges of the abdominal muscles were drawn downward and sutured to the remains of the glutei and the levator ani to form a muscular layer. A cigarette drain was inserted in the extraperitoneal space. Finally the skin was sutured.

A transfusion of 500 cubic centimeters of citrated blood was begun during the closure of the wound. The child was returned to his bed in good condition one hour and twenty minutes after the administration of the anaesthetic was begun.

The extent of shock during the operation is shown in Figure 3. The pulse was 108 at the beginning of the operation, and remained at that level for thirty-five minutes. It then rose gradually to 152 at the close. After transfusion, it fell to 120. The systolic blood pressure fell from 88 to 60 in thirty minutes. At this time three-quarters of a grain of ephedrine was given hypodermically. This was followed by a rise in systolic pressure to 80 and at the end of the operation it was 88. The diastolic pressure rose steadily during the operation period. There was thus very little operative shock. The child did not complain of pain during the procedure.

The patient made a good recovery and left the hospital walking with crutches on the twenty-second day after operation (Fig. 2). The roentgenogram made on discharge from the hospital is reproduced in Figure 6.

FIG. 7

Photograph of the femur, innominate bone, and tumor.

Pathological Examination

Figure 7 shows the denuded femur and innominate bone with the growth. The tumor sprang from the bone on the anterior surface of the femoral neck, and spread upward, downward, and around the shaft in the soft tissues. The head of the bone was not involved; the pelvic bones were also free from growth.

Histological Report

"The tissue consists of spicules of bone, or of osteoid tissue surrounded by layers and masses of large osteoblastic cells. The nuclei are large, oval, and vesicular with a single pink nucleolus when stained by the trichrome method of Masson. The nuclei occupy at least half of the cell body. Most of the cells have a rim of basophilic cytoplasm, and some seem to have a centrosome. A few have almost no cytoplasm. Quite often there is a tail of cytoplasm streaming out into the tissue. Mitotic figures are fairly common. These tumor cells, probably of osteoblastic origin, are arranged in layers about the bone spicules, and are not flattened against the bone like normal osteoblasts. There are a fair number of tumor giant cells; the younger ones have a basophilic cytoplasm; the older, eosinophilic with smaller nuclei and granular or vacuolated cytoplasm. There are usually not more than six nuclei in each giant cell. The advancing sides of the tumor areas have a narrow strip of loose fibrous tissue, the nuclei of which are arranged in parallel rows. Some of these fibrous-tissue cells show mitosis, and the impression is gained that these cells too are undergoing malignant change. The advancing edge of the tumor is in a straight line; no irregular infiltration can be seen. *Diagnosis:* Osteoblastic osteogenic sarcoma."

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END RESULTS IN 100 FRACTURES TREATED BY INTERNAL REMOVABLE FIXATION *

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In presenting methods of fixation of fractures requiring open surgery, it is presumed that those having the responsibility of treating difficult fractures are familiar with the principles of traction and manipulation and are prepared to operate when the circumstances require it. It is difficult to outline the indications for operative treatment because the factors of individual judgment and surgical skill are so important and identical results may be obtained by two surgeons using entirely different operative methods. Likewise, if a surgeon decides upon an open reduction, the proper method is that which in his experience has proved satisfactory. It would seem sound practice to have a working familiarity with several methods of fixation, but to understand thoroughly the application of a few well-selected appliances and to adapt them to varying conditions.

The method of fixation with a removable screw, described by Girard and the author [1], has been used in our Clinic for several years and in more than 100 cases. The simplicity of the operative technique and the excellent results obtained warrant further observation on this method.

If the fracture is comminuted or compound, the screw is not suitable for fixation. Oblique fractures are best for this type of fixation, but transverse fractures can be fastened satisfactorily by this method. For transverse fractures, a compression staple was designed, but this has rarely been used because a screw placed in a long oblique position seems more desirable.

TECHNIQUE

The technique is essentially the same as that described in the original publication [1], but, for convenience and to include some variations, the method is here outlined.

The fracture is exposed and reduced.

The fragments are grasped with a clamp and held securely for drilling. At this stage, careful attention is given to placing the drill holes. The object is not only to hold the ends approximated, but also to produce compression. The latter can be accomplished better if the screw is placed as nearly as possible at a right angle with the broadest surface of the fracture line. The screw of rustless steel is made in two sizes and four lengths. The distal end has deep wood-screw threads, which were found to have more resistance in cortical bone than the machine threads formerly

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 7, 1935.

used. A small beveled lock nut moves on the otherwise machine-threaded screw, and a wing nut is fixed on the end to facilitate introduction. The proper size of the screw is determined by estimating the length necessary to cause the screw to extend one-half an inch to two inches beyond the skin. The first drill hole must be slightly larger than the screw and should extend only through the first or proximal fragment. Chipping the cortical surface facilitates starting the drill. The drill should be in good condition, for a dull drill makes a simple procedure difficult. When the drill has penetrated to the second fragment, it is removed and replaced by a drill slightly smaller than the screw. The author has had difficulty in obtaining good drills of this size. Often considerable length is required because the second drill should penetrate the distal cortex; when the screw is to be placed in an extremely oblique position, as for a transverse fracture, four or five inches of drill length may be required. The most practical type of small drill is one made from rustless steel and sharpened as is a Kirschner wire. Several lengths are available and there is no danger of breaking, as has occurred several times in the writer's experience with long hard drills of small caliber.

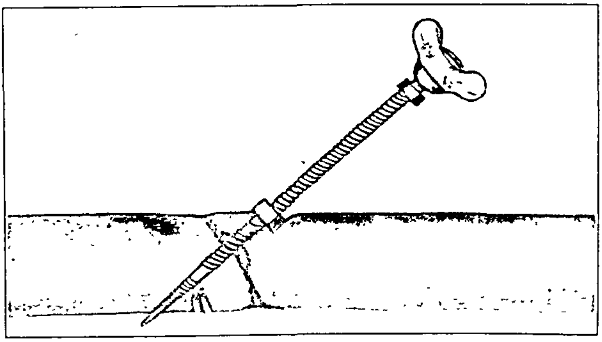

Fig. 1

Carrell-Girard screw. Note the deep threads at the end of the screw and the machine threads on the proximal three-quarters of the screw.

After the second drill hole has been completed, the screw is inserted. It then passes freely through the first fragment and engages the second. The wing nut, fixed on the proximal end of the screw, enables one to extend the screw to the desired depth with finger pressure. The small nut, which moves freely on the screw, is now brought firmly against the proximal fragment and tightened with pliers.

If the screw falls in line with the incision, the latter is closed around it. The end of the screw which projects beyond the skin is covered with dressing. Should it be found desirable to place the screw at some other angle than one conforming to the line of incision, it can be placed through a stab wound, preferably after the drill holes have been completed. The screw will then be away from the line of incision, which is to be desired when feasible.

Formerly, the end of the screw was anchored securely to give an added point of fixation. Theoretically, this is correct and should be done when the plaster is closely applied as in the case of the forearm or the leg. In the case of the femur or the humerus, there is always slight movement of

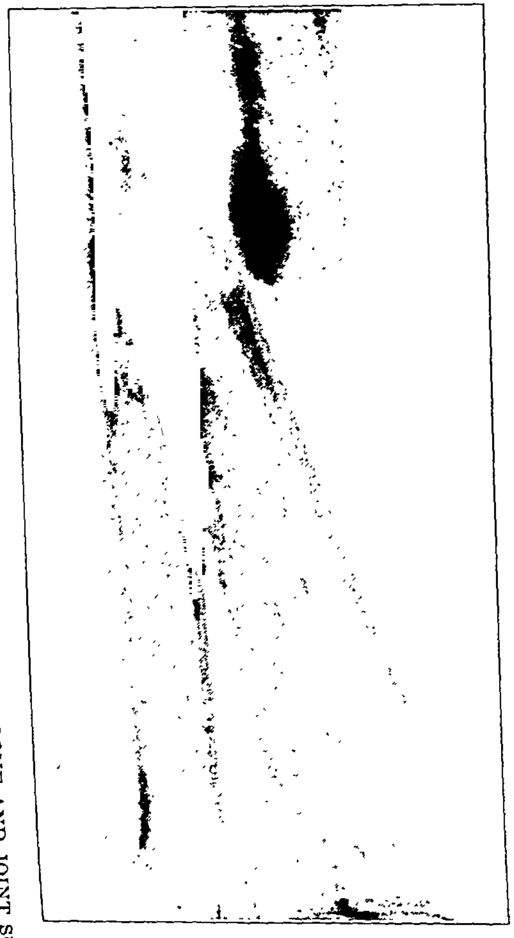

Fig. 2-A

Recent fracture of the radius, ten days after injury. Manipulation unsuccessful.

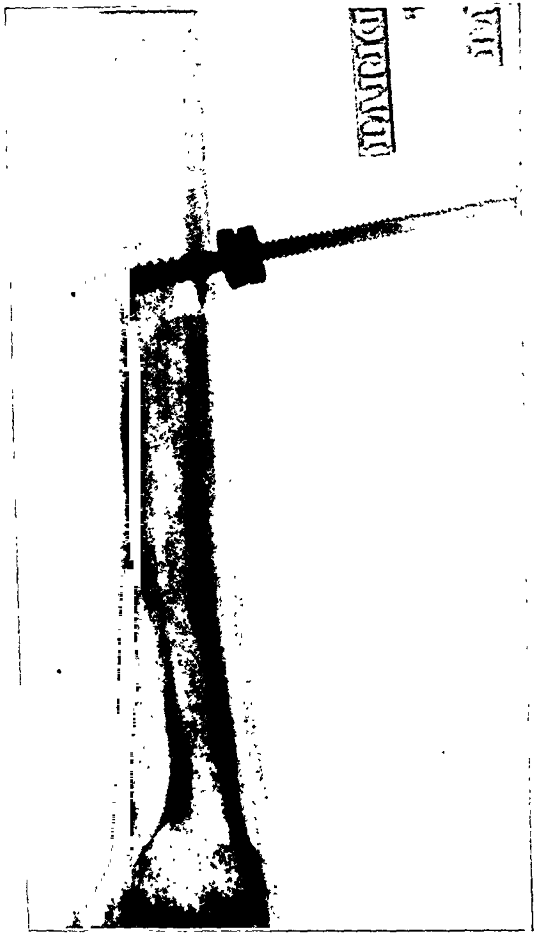

Fig. 2-B

Removable screw in place.

Fig. 2-C

Union has taken place in seven weeks.

the part within the plaster and, to compensate for this, the plaster is cupped around the end of the screw, but is free enough to permit a little movement. However, it rests snugly against the end of the screw, which controls the tendency to deviation of the fragments.

After completion of the dressing, which always includes plaster fixation, the operative wound is not disturbed for three weeks. At this time, a window is cut, the stitches are removed, and, if the roentgenograms show adequate callus, the screw is also removed. In no case has it been found necessary to leave the screw in position longer than four weeks. At the time of removal, the screw will be tightly fixed, but, by means of a few turns, it may be released readily. Since the lock nut is beveled, it may be drawn through the muscles and the fascia without undue tension. Patients frequently leave the hospital after a few days and return to the office for removal of the screw.

FINDINGS

This method of fixation has been used in slightly more than 100 cases. A few of these were compound fractures. Several other cases have been

Fig. 3-A

Fracture of the tibia, after manipulation and traction for five days.

Fig. 3-B

Six weeks after removal of the screw; nine weeks after operation.

treated by this method during the past few months but are not included in the report.

Non-Union and Union

In 100 consecutive cases of clean fractures, there was one case of non-union. This was a fracture of the forearm in which two manipulations under anaesthesia had been done and the fragments were in malposition two weeks after the injury when the open reduction was performed. The fracture in the middle of the radius, which was treated by closed reduction, united. The fracture in the middle of the ulna, which was reduced at open operation and fixed with a screw, did not unite and later a bone-grafting operation was necessary.

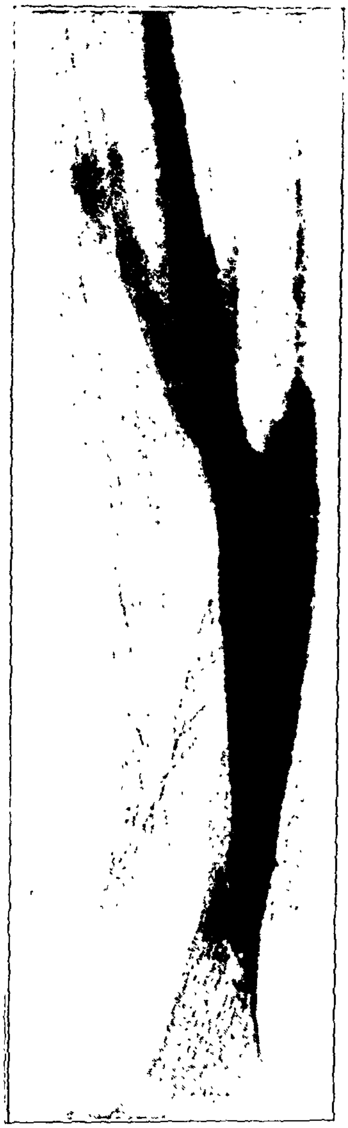

FIG. 4-A

Comminuted fracture of the tibia four months after injury, with malunion.

FIG. 4-B

Open reduction has increased the length three-quarters of an inch without detaching the upper segment of the fracture. The lower segment is held in contact with the removable screw. The fibula has been divided to gain length.

FIG. 5-A
Fracture of the olecranon.

FIG. 5-B
Fragments held in position by the screw.

FIG. 5-C
Four weeks after injury.

In 60 per cent. of the cases, two or more manipulations had been done prior to operation. Union was a little more rapid in those cases in which several manipulations had not been done. Union was more rapid in the few cases in which the operation was performed within forty-eight hours than it was in those cases in which the operation was postponed for eight or ten days, as was done in most of the cases. In the entire series, the time required for union was approximately 25 per cent. longer than for similar cases in which good position of the fragments could be effected early and by closed reduction. However, union was approximately 35 per cent. faster than in similar cases where the reduction was not very satisfactory, but was considered good enough to make operation unjustifiable and to warrant treatment by closed methods.

In addition to the more rapid union, the incidence of non-union (1 per cent.) was much less than in the group of similar fractures in which only fair reduction had been obtained and which had been treated by closed methods.

Infection

In no cases in the group of simple fractures did bone infection develop. Most of the wounds remained dry up to the time of the removal of the screw, when serum moisture was evident for a few days. In a few cases

FIG. 6-A
Compound fracture of the femur, four months after injury. Skeletal traction had been maintained for sixty days.

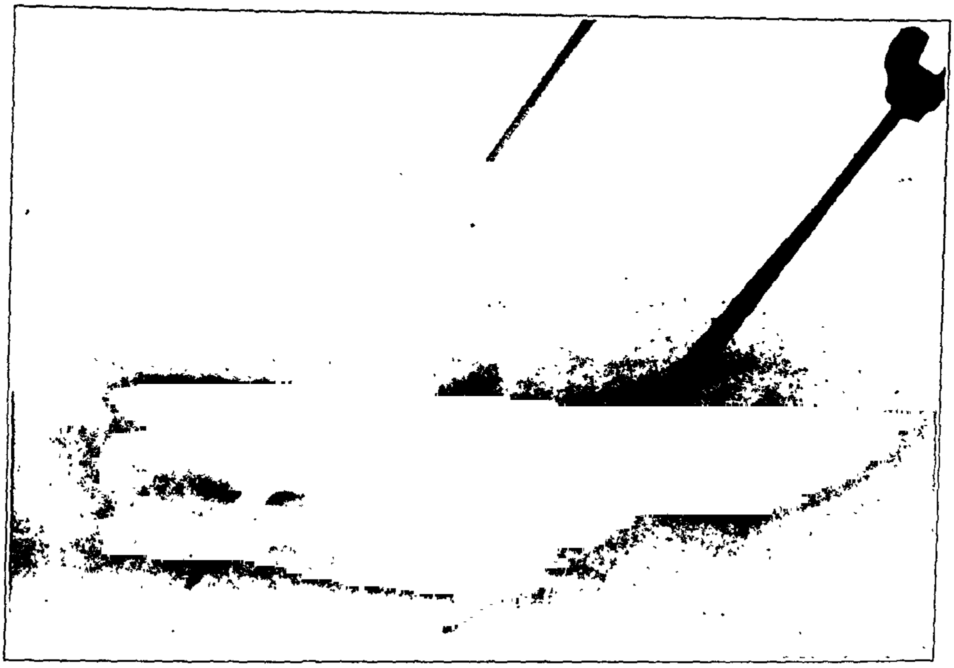

FIG. 6-B
Open reduction; very little callus; fixation by two screws.

FIG. 6-C
Union in ninety days.

Fig. 7-A

Oblique comminuted fracture of the lower third of the tibia. Traction had been applied for one week. Length had been secured, but poor contact of the fragments had resulted.

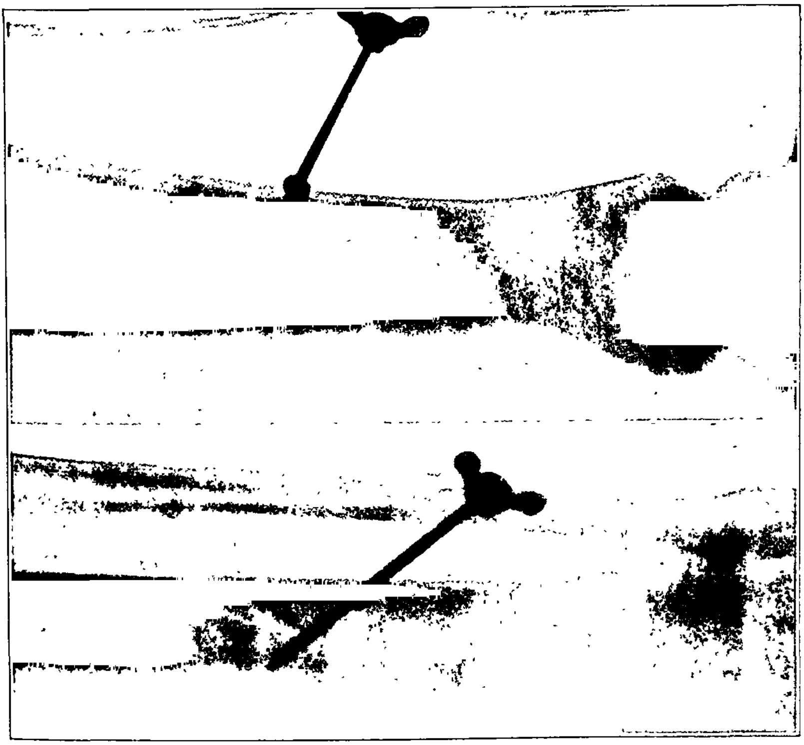

Fig. 7-B

In attempting to reduce the fracture by the open method, a large fragment was almost detached. Osteotomy of the fibula was then done to lessen the difficulty of reduction. Fixation of the fragments was obtained by a screw.

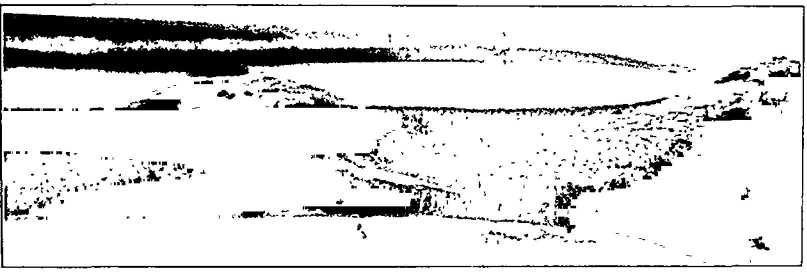

Fig. 7-C

Two months after operation; very good union.

(10 per cent.), there was at the time of removal of the screw considerable soiling of the dressing around the screw, but this condition cleared up within a few days without contamination of the bone. In the earlier cases, this method was employed with some trepidation in anticipation of this added source of contamination. It seemed that we were violating a surgical principle in carrying a foreign body through the skin to the site of a simple fracture. Therefore, it has been our purpose to carry out a most meticulous technique for exposing and reducing the fracture. The tissues are handled gently and when the operation is finished the field is left perfectly dry. The sterile dressings, applied immediately after the operation, are left undisturbed for the long period to avoid chances of contamination. The operation unquestionably offers more opportunity for infection than does a closed operation where there is no foreign body projecting through the skin.

Final Position on Healing

The screws held the fragments in whatever position they were placed at the time of operation. In 14 per cent. of the cases, there was some comminution and an accurate reposition could not be done. In these cases, union was slow, but satisfactory function was finally obtained. For this type of fracture a screw should not be used and, if open operation is necessary, some other method of fixation should be applied. In 20 per cent. of the cases, there was some change in the position of the fragments after removal of the screw; in most of these cases, there was a slight deviation, such as outward bowing of the femur or posterior bowing of the ulna. This defect has been better controlled in the more recent cases by careful attention to splinting after removal of the screw. In fractures of the femur, where this tendency is greatest, a compression pad should be placed against the thigh after removal of the screw. In the window which is cut for removal of the stitches and the screw, a firm pad is placed and held by a metal pad with a turnbuckle compressor in order that position may be maintained until the bone is firm enough to resist muscle contraction.

ADAPTABILITY

The method has been used satisfactorily for oblique and transverse fractures in the shafts of all of the long bones of the extremities with the exception of the fibula. It is particularly suited to the fixation of fractures of the olecranon, because the olecranon fragments can be securely fastened and permit a right-angle position for ambulatory treatment. This procedure should not be used in comminuted fractures, or in compound fractures. One compound fracture was perfectly reduced and fastened with a screw. Both fragments necrosed up to the point where the drill hole was placed. In cases where the fragments can be fairly accurately replaced, this method is not as good as the closed method of treatment.

1. Carrell, W. B., and Girard, P. M.: Removable Internal Fixation in Fractures. J. Am. Med. Assn., XCVI, 670, 1931.

PELVIC ABSCESSES ASSOCIATED WITH ACUTE PURULENT INFECTION OF THE HIP JOINT *

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Acute purulent infection of the hip joint is not a rare disease. Consequently, medical literature contains many articles concerning this subject, but only two factors are stressed,—the type of surgical drainage and the type of immobilization. Little can be found regarding the mode of infection and the complications. To summarize the literature on pyarthrosis of the hip joint, the important items are early diagnosis, surgical drainage by one of several anterolateral or posterior approaches, and immobilization in traction or a plaster cast. If the infection is not severe, the treatment advocated consists of aspiration and immobilization, or immobilization alone[5].

During a period of eleven months on the Orthopaedic Services of the Children's Hospital and the General Hospital, Cincinnati, seven cases† of purulent infection of the hip joint were encountered in which the joint infection was associated with adenitis of the inguinal lymph nodes and iliac abscess. The early appearance of the iliac abscess, which was present in the majority of the cases on admission to the hospital, offered considerable difficulty in diagnosis. Did the abscess represent an appendiceal abscess, an osteomyelitis of the ilium, or an idiopathic retroperitoneal abscess? The children, varying in age from six to fifteen years, were all acutely ill and required immediate attention. Four patients in this series had a septicaemia, and five of the seven had a recent or existing otitis media or mastoiditis. Because of the bizarre clinical picture, two of the children were subjected to immediate laparotomy; due to a mistaken diagnosis, one of these patients was operated upon for an appendiceal abscess. Six of the seven patients had iliac abscesses on the right side. Although hip symptoms existed, irritation of the iliopsoas muscle was thought to explain these findings. Later study of the roentgenograms showed early changes in the hip joint, but these could easily have been overlooked.

In a consideration of the association of iliac abscess and purulent infection of the hip joint, the question may well be raised: Did the iliac abscess precede the involvement of the hip joint, or vice versa? On consulting the literature, the authors found just two articles on this subject. Sáinz de Aja[6] reported a case of staphylococcic coxitis with complication of the inguinal glands. However, this patient was a male adult who had, in addition to an infected hip, an active gonorrhoeal infection, which rather

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 14, 1936.
† See note, p. 427.

complicated the picture. Gravinghoff[3] reported two cases of infants with extensive multiple osteomyelitic foci, who had retroperitoneal abscesses. The lesions were not confined to the hip joints and the clinical pictures were far from clear.

Slowick[7], in reporting sixty cases of purulent infection of the hip joint seen in the Boston City Hospital over a period of fifteen years, did not mention the occurrence of iliac abscess. He states: "The occasional case of an abscess outside of the capsule of the hip joint does not present any unusual difficulties." In the sixty cases, drainage was accomplished by posterior incisions in thirty-two cases, anterolateral incisions in twenty-seven cases, and an undescribed medial incision in one case. Did this one case represent a pelvic abscess?

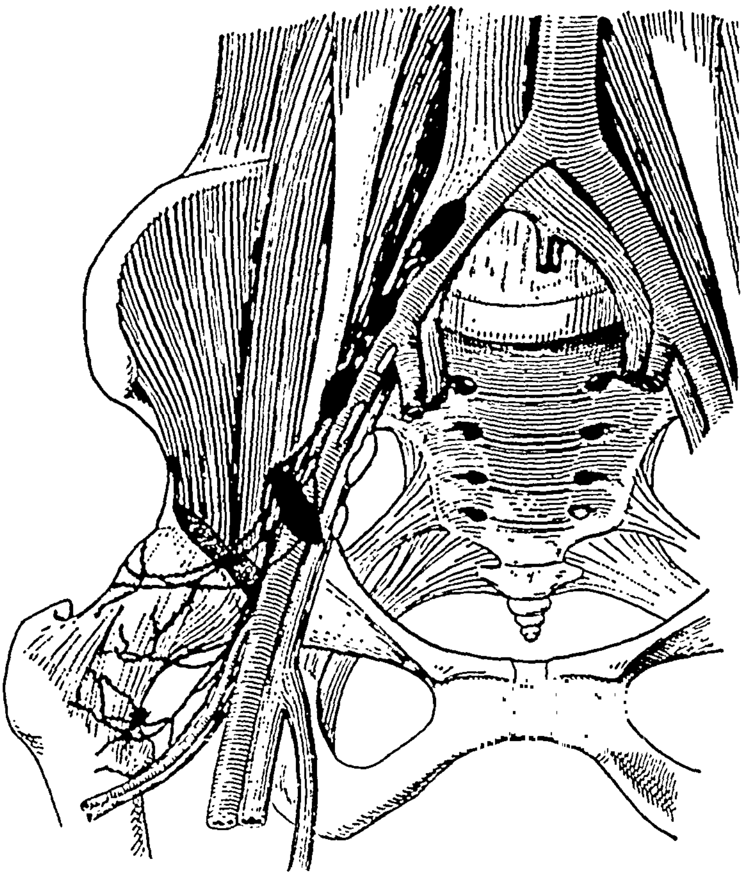

FIG. 1

Lymphatic drainage of the anterior and superior surfaces of the hip joint. The glands lie along the external iliac artery. (From paper by C. N. Alivisatos[1]. *Reproduced by courtesy of Masson & C^ie^, Paris.*)

Caldwell[2] reported eighteen cases of purulent infection of the hip in children under fourteen years of age, in which the drainage was accomplished by anterior incisions in twelve cases, by posterior or Ober incisions in two cases, and, in four cases, by incisions on the inner aspects of the thighs where the abscesses were pointing. On reading this article, one concludes that in these four cases the mesially pointing abscesses were extensions from the hip-joint infections, but were they not pelvic abscesses?

Guthrie and Middleton[4] reported a case of left-sided mastoiditis with lateral sinus thrombosis in which a purulent infection of the right hip joint developed. Drainage of the hip joint was done through a lateral incision, but satisfactory convalescence did not begin until through-and-through drainage was established from the hip joint to the adductor region. The possibility of a pelvic abscess presenting in the adductor region was not considered.

It is evident from the foregoing references that the presence of pus in the adductor region of the thigh has been noted in a number of instances in association with pyogenic infections of the hip joint. The possibility that these abscesses do not represent direct extension of the hip-joint infection has not been considered.

There is a unanimity of feeling regarding the manner of infection of the hip joint,—namely, that the infection is hematogenous, except in those instances in which it occurs directly from without. Whether or not the hip joint becomes infected by extension from a neighboring lesion of the innominate bone does not concern this discussion. Suffice it to say that, in the seven cases to be presented, the primary lesion in the hip joint was either synovial, cervical, or epiphyseal, as indicated by the roentgenographic findings. In no case were there clinical or roentgenographic findings suggesting the presence of osteomyelitis of the ilium or perforation of the acetabulum by infection.

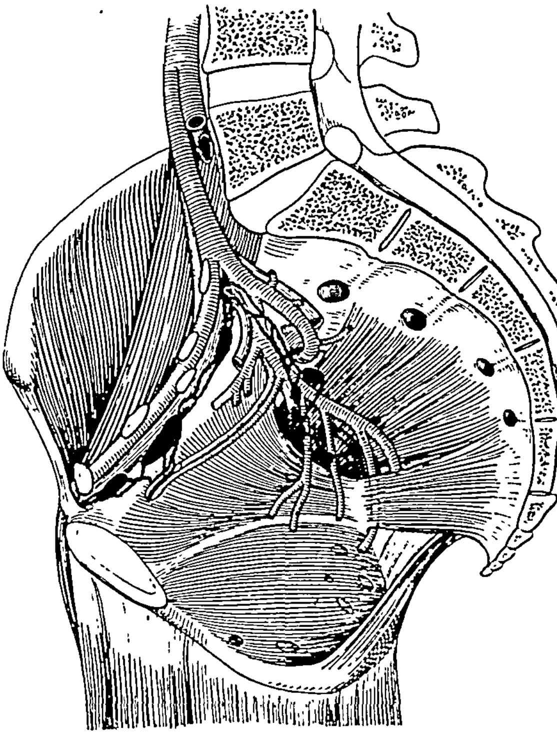

Fig. 2

Lymphatic drainage of the posterior and inferior surfaces of the hip joint. In this sagittal section, the glands are shown lying along the hypogastric artery, as well as the external iliac glands. (From paper by C. N. Alivisatos[1]. *Reproduced by courtesy of Masson & Cie, Paris.*)

A careful study of many of the text-books and publications concerning the lymphatic drainage of the hip joint fails to show a single dissenting opinion. All writers agree that the intracapsular structures of the hip joint are drained by lymphatics emptying into the group of glands situated about the external iliac artery, except a portion of the hip joint posteriorly in which drainage is into the glands about the hypogastric artery. These two groups of glands, variable in number, drain into the glands about the common iliac artery, and connect with the more proximally situated presacral glands. The superficial inguinal glands, which drain the anterior two-thirds of the perineum, and the femoral glands, which drain the leg, combine as a single group and have

afferent lymphatics draining into the external iliac glands. Likewise, the single gland of Cloquet or Rosenmüller, situated beneath Poupart's ligament, just mesial to the femoral vein, drains into the external iliac chain[1]. (See Figures 1 and 2.) The external iliac glands, grouped about the artery, are retroperitoneal and lie immediately over the thin enclosing sheath of the iliopsoas muscle. Infection of the external glands by extension along the lymphatics from the hip joint may be followed by necrosis and abscess formation, the abscess lying on the iliopsoas muscle. It is well recognized that an increasing abscess *in this location* extends upward in the false pelvis and gravitates downward either into the true pelvis or along the iliopsoas muscle. As this abscess lies anterior to the iliopsoas muscle, it would tend to extend mesially and downward, presenting either on the anterior surface of the pectineus muscle, and thence beneath the skin, or along the pectineus muscle and downward between the adductor longus and the adductor brevis muscles. As the iliopsoas muscle extends anteriorly over the hip joint in its course distally, it would seem unlikely that an abscess situated on the anterior surface of this muscle would extend to or into the hip joint or its capsule.

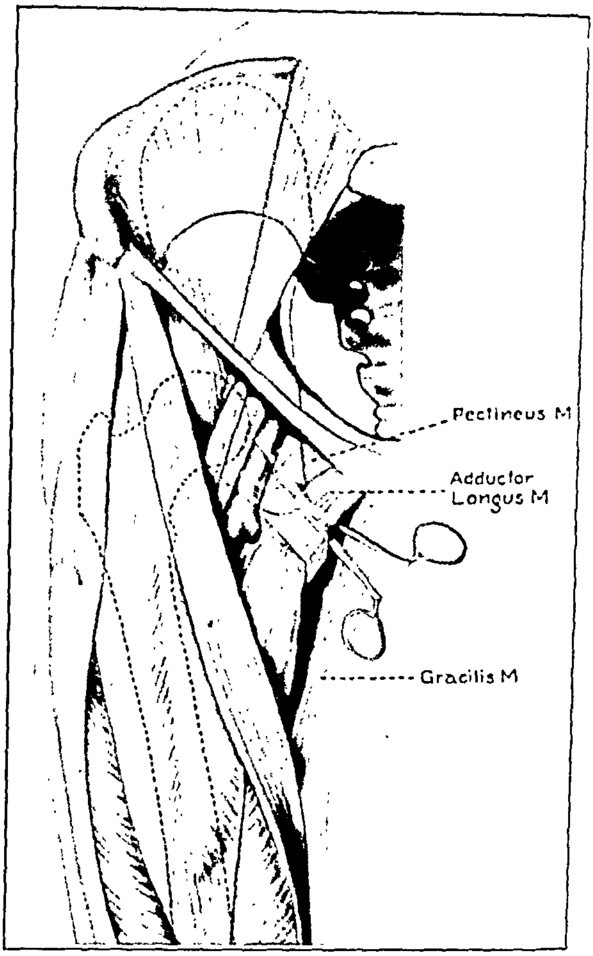

Fig. 3

Diagrammatic representation of a retroperitoneal abscess arising from the external iliac glands and dissecting downward on the surface of the iliopsoas muscle and thence mesially to the adductor region. Surgical approach to this abscess is shown extending beneath the adductor longus muscle. Superiorly, a second line of incision is shown for an unusually large abscess. *It will be noted that the abscess is not in contact with the hip joint.*

In a case in which there is a recognized pyarthrosis of the hip joint and a palpable fluctuant iliac abscess, the question naturally arises whether the hip-joint involvement is secondary to the lymph node or abscess infection. In the series of cases to be presented, the clinical evidence points to the hip joint as the primary seat of infection. No similar cases have been reported.

Seven cases of purulent infection of the hip joint, associated with inguinal lymphadenitis and iliac abscess, were encountered. In six of these cases, the right hip was involved. The age limits were from six

TABLE I

SUMMARY OF SEVEN CASES OF ACUTE PURULENT ARTHRITIS OF THE HIP JOINT WITH ASSOCIATED ILIAC ABSCESSES ARISING FROM SECONDARY INFECTION OF THE EXTERNAL ILIAC GLANDS

ETIOLOGY	
Otitis media or mastoiditis	5 cases
Trauma	1 case
Idiopathic	1 case
COMPLICATIONS	
Associated septicaemia (repeated positive blood cultures)	4 cases
THERAPY	
Immobilization:	
Without surgery	1 case
With surgery	6 cases
Drainage:	
Hip joint	
Anterolateral	2 cases
Anterolateral and posterior (Ober)	1 case
Supra-Poupart or abdominal	4 cases
Adductor or Ludloff incision	4 cases*
Combined adductor and abdominal	2 cases
AVERAGE DURATION OF INFECTION	
Before admission:	
Six days	5 cases
Sixty days	1 case
Ninety days	1 case
After admission:	
Seventy-five days	6 cases
One year	1 case
END RESULTS	
Ankylosis (without deformity)	3 cases*
Marked limitation of motion	3 cases
Good, useful motion	1 case

* Bilateral in one case.

years to fifteen years. All of the patients were white children,—four girls and three boys. Five of the patients had a preceding or existing right-sided otitis media. Of these five patients, three had a mastoiditis; and two of this latter group, a lateral sinus thrombosis. Of this group of five patients, four had a hemolytic streptococcus septicaemia, proved by more than two consecutive positive blood cultures. One of the seven patients had, according to the history, a secondarily infected vaccination. The seventh patient had a history of a severe blow in the left groin.

Fig. 4

Case 1. July 4, 1934. Roentgenogram of pelvis, including both hip joints and showing abduction and external rotation of the right hip joint. On careful inspection, a large soft-tissue shadow, a pelvic abscess, is seen displacing the intestinal outlines to the left. Also, the right femoral head is seen somewhat laterally displaced from the acetabulum by exudate.

Fig. 5

Case 1. July 20, 1934. Roentgenogram of pelvis, including both hip joints and showing extensive soft-tissue infiltration of the right thigh and subluxation of the right hip joint by intracapsular exudate.

Fig. 6

Case 1. September 17, 1934. Roentgenogram of pelvis, including both hip joints. Subluxation of the right hip joint has been reduced by skin traction. The shadow of the iliac abscess is no longer visible, the abscess having been drained by an adductor incision. Progressive changes are shown in the hip joint.

Fig. 7

Case 1. December 11, 1934. Roentgenogram of the pelvis, including both hip joints. End result of the infection of the right hip joint: active motion: flexion, 50 degrees to 170 degrees; active adduction, 35 degrees; and active abduction, 15 degrees.

With the exception of the third case, in which the right hip joint was first infected and at a much later period the left hip joint became involved, the seventh case represents the single involvement of the left hip joint.

On admission to the hospital all of these patients were critically ill. In only two instances, were the children admitted on the Orthopaedic Service,—the patient who had received the injury in the groin and the patient with a streptococcic septicaemia, who had had a recent otitis media. The other five patients were admitted either on the Otological, Pediatric, or Surgical Services, signifying that the more prominent findings were either the pelvic abscess or the mastoiditis. In retrospect, however, the histories and findings indicate that the hip lesions were present at the time of admission to the hospital. In one instance, drainage of the large pelvic abscess was performed by a general surgeon on the assumption that the lesion represented an appendiceal abscess. This statement is made, not in a critical manner, but to emphasize the difficulties of this diagnostic problem. A second case was operated on as a possible iliac osteomyelitis.

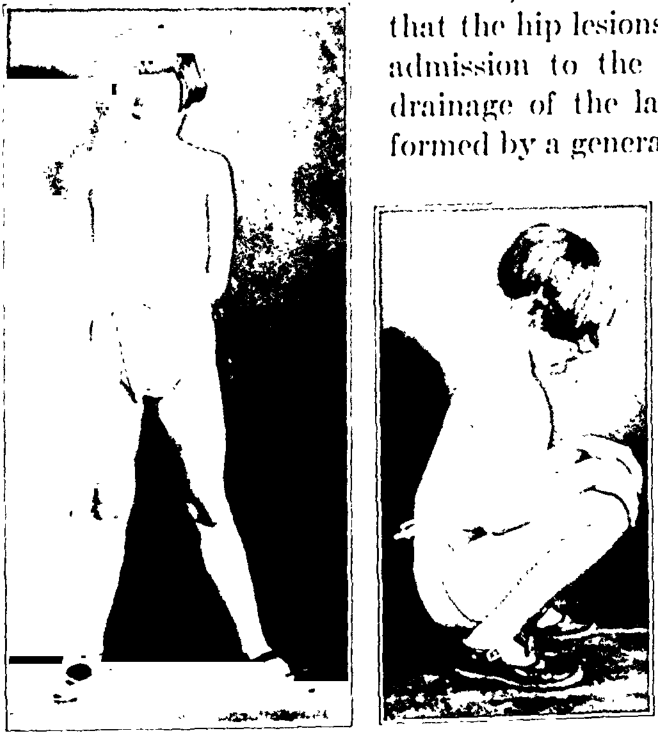

Fig. 8

Case 1. December 27, 1935. The operative wound is healed. For range of motion, see Fig. 7.

In only one of this series of seven cases was the hip lesion probably primarily osseous in origin, involving the cervical area. So far as could be determined, in the remaining six cases the lesions were presumably synovial in onset. All of the seven patients recovered.

The infecting organism was a hemolytic streptococcus in three cases, a non-hemolytic streptococcus in one case, a staphylococcus in two cases, and in the seventh case the bacterium was not recovered, although a pelvic abscess was palpated and aspirated.

With some few variations, the physical findings in this group of cases were the same. A feverish, sick child lay with the affected hip abducted, externally rotated, and flexed to about 90 degrees. In most instances, there was a visible fulness both above and below Poupart's ligament. On palpation of the hip joint, all motions were restricted by muscle spasm and accompanied by severe pain. In several instances, distention of the hip joint was palpable, but this was not invariably the

case. The inguinal glands were enlarged and prominent. Deep pressure immediately above Poupart's ligament and just above the anterior third of the iliac crest encountered a firm hemispherical mass, slightly tender. True fluctuation in this mass was occasionally discernible. Likewise, in several instances, simultaneous pressure over the iliac abscess and below the mesial third of Poupart's ligament elicited fluctuation.

From the preceding discussion, it has been noted that, whereas the description of the involved joint would have only one diagnostic suggestion to an orthopaedic surgeon—infected hip joint—other diagnoses may seem more likely to the pediatrician or the general surgeon because of the associated clinical picture. As in all instances of acute purulent infection of a joint, early roentgenograms show relatively slight abnormal changes, consisting primarily of soft-tissue involvement and possible cartilage destruction. In two cases in this series, the hip-joint involvement was not recognized until six weeks had elapsed following admission to the hospital. In the remaining five cases, the correct diagnosis was made in from one to seven days after admission.

On reviewing the roentgenograms, not only could some abnormality of the hip joint be seen in each instance, but likewise in most cases a soft-tissue shadow of the iliac abscess could be identified.

From the experience of treating this series and numerous additional cases of acute purulent infection of the hip joint with an unrecognized iliac abscess, it is concluded that the ideal therapeutic plan is as follows:

1. Complete and careful physical examination and roentgenographic examination to determine the site of infection with reference to localization of exudate accumulation.
2. General supportive therapy with emphasis on the administration of adequate fluids parenterally.
3. Application of skin traction to the affected leg.
4. Early blood culture. Subsequent multiple and frequent small blood transfusions if the blood culture is positive.
5. Aspiration of the hip joint to verify the diagnosis, followed by
6. Incision and drainage of the joint, the site of the incision to be determined by the chief site of pus collection
7. Incision and drainage of the pelvic abscess. The longitudinal incision of Ludloff on the mesial aspect of the thigh, extending between the adductor longus and gracilis muscles and bluntly either over or under the pectineus muscle, as indicated, to the abscess overlying the iliopsoas muscle. Drainage to be maintained by vaselin-gauze wicks. In those cases where the abscess presents anteriorly over the pectineus muscle immediately below Poupart's ligament, the incision may be made there, but hemorrhage from the great vessels is more likely at this site. If fluctuation or infiltration of the soft tissues is not felt in the adductor region of the thigh, the abscess of course had best be drained at the site of presentation, but preferably below Poupart's ligament.

Sometimes, in spite of changes in the hip joint, as seen in the roentgenogram, in the absence of pus in the joint, drainage of the iliac abscess alone may suffice. In the two cases in which the iliac abscess was drained above Poupart's ligament, faecal fistulae developed and healing was delayed until the adductor incision was made. Adequate emptying of the abscess did not follow supra-Poupart drainage. If the iliac abscess is very large, ideal drainage should consist of two incisions,—first, the adductor incision and, second, a three-inch oblique incision extending above the posterior iliac crest as in the incision utilized for ureteral inspection.

The hip-joint incision of choice is the posterior muscle-splitting incision of Ober. In some cases, however, the usual longitudinal anterolateral incision between the sartorius and vastus lateralis and the tensor fasciae femoris muscles may result in more direct drainage. In the case of a hip-joint abscess of extreme size, both of the incisions may expedite complete drainage.

In reviewing this series of seven cases of iliac abscess associated with purulent infection of the hip joint, the authors would again emphasize the difficulty of diagnosis. The general surgeon, as well as the orthopaedic surgeon, should learn to recognize this apparently unusual syndrome. Of especial significance is the association of these lesions with otitis media and mastoiditis. Two questions, so far unanswered, are offered for consideration. If in seven consecutive cases of purulent infection of the hip joint complicating iliac abscesses occurred, are these iliac abscesses frequent but unrecognized lesions? When exploring acute purulent infections of the joint for drainage, have iliac or prepsoas abscesses been unwittingly drained? It is conceivable, certainly, that an extracapsular iliac abscess may be unwittingly drained satisfactorily through a hip-joint incision, whether it be the posterior incision of Ober or the anterolateral incision, if the surgeon dissects through the joint capsule. Likewise, as in two cases of this series, although destructive in nature, the hip-joint infection may heal without drainage, if the iliac abscess has been adequately drained. In one case of this series, and in four cases without recognized iliac abscesses, satisfactory healing has occurred without surgical drainage, but with adequate and prolonged immobilization of the joint.

CONCLUSIONS

1. A secondary iliac abscess, arising from extension through the lymphatics to the external iliac glands, may be a relatively frequent complication of acute purulent infection of the hip joint.

2. This association of lesions presents a most difficult diagnostic problem in the acutely ill child.

3. Otitis media and mastoiditis are frequently associated with pyarthrosis of the hip joint.

4. The primary therapy of acute purulent infection of the hip joint should be general and supportive in type with immobilization of the extremity by traction.

5. Drainage of the iliac abscess accompanying hip-joint infection may best be accomplished in most cases by an adductor incision.

6. If immobilization is adequately applied and the patient is under close observation, surgical drainage of the hip joint may not be necessary.

7. The degree of function following acute purulent infection of the hip joint is variable, ranging from excellent motion to complete ankylosis.

8. The question is offered: Are pelvic abscesses frequent but previously unrecognized complications of acute purulent infection of the hip joint?

NOTE: Since writing this paper, one of the authors (J. A. F.) has operated on a child, nine months of age, with a very large left iliac abscess associated with an acute purulent infection of the left hip joint. This lesion was preceded by an acute retropharyngeal cellulitis. The blood cultures were negative. The child is recovering.

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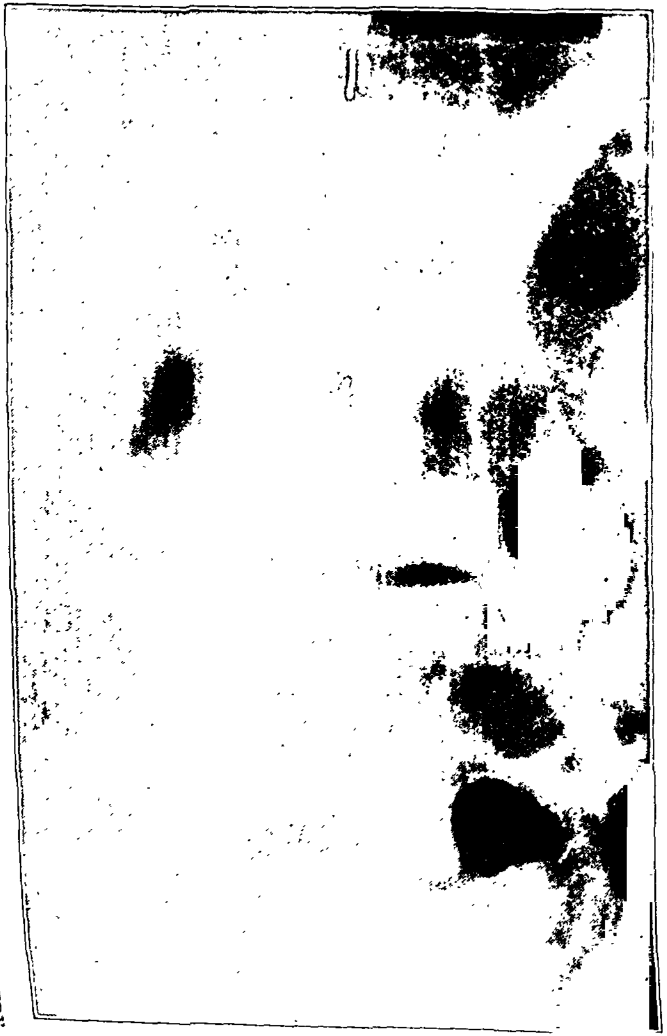

FIG. 4

FIG. 4

Roentgenogram (retouched). Thinning of the second disc has allowed the second and third bodies to approach each other. The posterior articulations have not subluxated, so that the second foramen remains normal in size and a lumbar kyphos has been produced at this level. Some degree of stabilization has been attempted by the spur formation. The third disc is also thinned, with the third and fourth bodies approaching each other. At this level, however, the posterior articulations have subluxated. Because of inclination of the plane of these joints, the fourth body has been wedged forward beneath the third. As a result, the third intervertebral foramen has become distorted in both the anteroposterior and longitudinal directions.

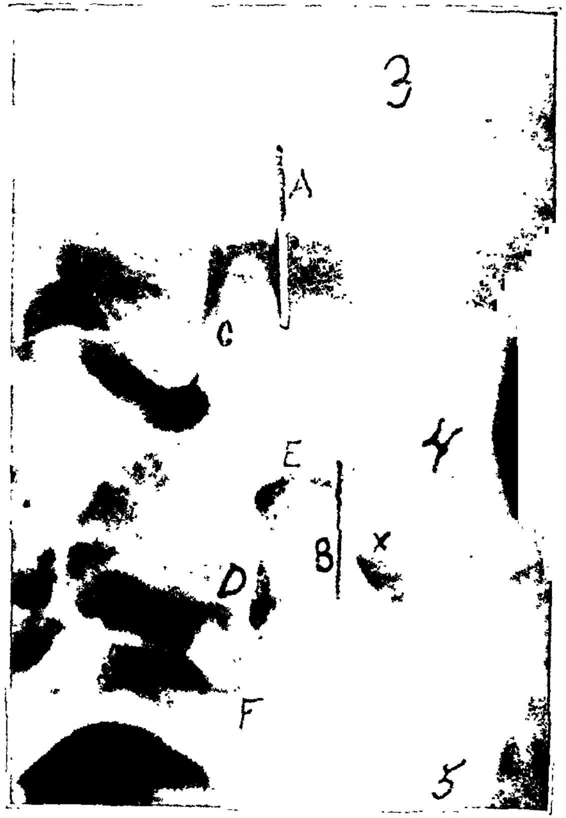

FIG. 5

FIG. 5

Oblique stereoscopic roentgenogram (retouched) made with the sagittal plane of the patient at an angle of 45 degrees to the horizontal plane. The third disc is normal; the fourth disc is thinned by an old herniation of the nucleus pulposus; sclerosis about this herniation is shown as a semicircle at *X*. Line *A* represents the normal interpedicular diameter of the third intervertebral foramen. *B* is the contracted interpedicular diameter of the fourth foramen. The normal third apophyseal (posterior) articulation is shown at *C*, but *D*, the fourth articulation, is subluxated, so that the superior articular process of the fifth body impinges against the pedicle of the fourth at *E* and the inferior articular process of the fourth body impinges against the lamina of the fifth at *F*. This patient had lumbar pain with unilateral muscle spasm of six months' duration, which was relieved after fifteen months of immobilization by plaster and a brace.

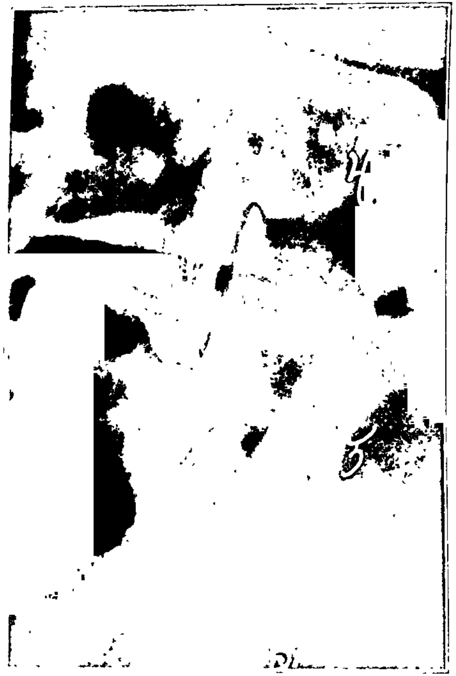

Fig. 6

Oblique view (retouched), showing thinning of the fourth disc with apophyseal subluxation and bony impingement. The superior articular process of the fifth body has eroded a notch into the under surface of the fourth pedicle, causing recurrent attacks of low-back pain, sciatica, and contralateral scoliosis of six years' duration.

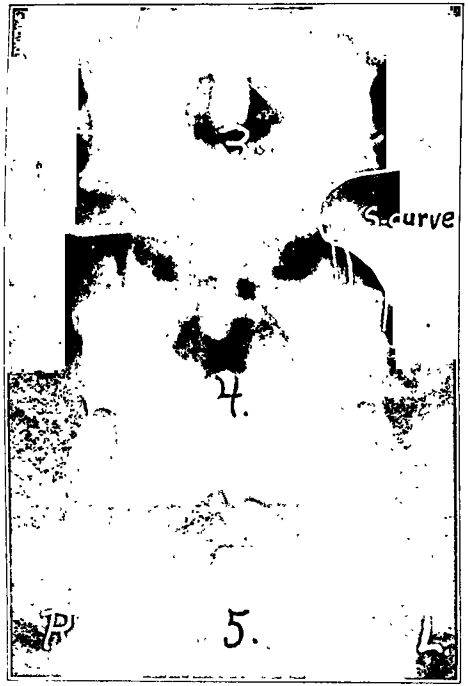

Fig. 7

Normal anteroposterior view (retouched), showing the S-curve which follows the under surface of the transverse process, the lateral surface of the inferior articular process, and extends straight across the apophyseal joint and thence along the lateral surface of the superior articular process from the body below. This curve can be seen in its normal condition between the third and fourth bodies on the right side and on both sides between the fourth and fifth vertebrae.

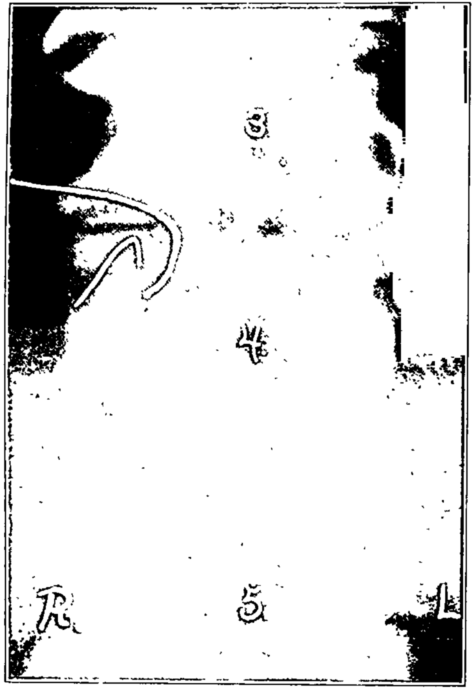

Fig. 8

Anteroposterior view (retouched), showing apophyseal subluxation with break in the S-curve where it crosses the joint, because the articular processes have slipped past each other. This is outlined between the third and fourth bodies on the right side, and the break in the continuity of the curve is easily visualized between the fourth and fifth bodies on both sides.

with the patient standing. It may also be recognized by a break in the S-curve as seen in the anteroposterior view.

DESCRIPTION OF THE S-CURVE

In the anteroposterior view, centering through an intervertebral disc of normal thickness in the lower lumbar region, an S-curve is formed, the line following the under surface of the transverse process and the lateral surface of the inferior articular process, and extending across the apophyseal joint and along the lateral surface of the superior articular process from the body below (Fig. 7). This curve is seen best if the plane of the articulation is nearly sagittal, but it can be made out even when the articulation is not in the sagittal plane. In case there is an apophyseal subluxation, with thinning of the disc, such a view shows a jog in the S-curve at the point where the posterior articulations have slid past each other (Fig. 8).

In certain cases of marked lordosis, some of the patient's weight is thrust posteriorly onto the posterior articulations of the spine, so that an apophyseal subluxation may take place.

In cases of scoliosis, there may be subluxation if sufficient rotation of the spinal bodies has not taken place; usually, however, even in extreme cases of scoliosis, apophyseal subluxation does not seem to be present if the bodies are rotated.

As a result of sprain or thinning of the anterior portion of the disc, reverse subluxation of the apophyseal joints may be visualized as a pulling apart of the articular processes.

SYMPTOMS

Among the clinical evidences of this condition may be noted tenderness to deep pressure, muscle spasm, and restricted motion with pain in the back. Referred symptoms may be those of radiculitis[4], the pain corresponding in distribution to that of the involved nerve root. The patient may complain of sciatica with disturbance of the reflexes, muscle atrophy, and Dejerine's sign,—that is, pain upon coughing or sneezing. There is usually, however, no pain upon pressure directly over the nerve; pain is present only when there is pressure over the nerve root. Homolateral or contralateral scoliosis may be present.

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THE PROBABLE ADAPTATION OF UTILITARIAN IMPLEMENTS FOR SURGICAL PROCEDURES BY THE "MOUND BUILDERS" OF EASTERN ARKANSAS *†

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The adaptation of common utilitarian implements for surgical procedures by various people in ancient and in medieval times is a known historical fact. The first mention of the use of the cautery is in a case of an unidentified tumor of the breast, which was recorded in the ancient Egyptian literature[1]. The instrument employed in this case was the fire-stick or the fire-drill[2]. In the Fourth Dynasty of ancient China (2900 to 2750 B. C.), some sort of drill, probably metal, was employed for drilling a hole in the mandible to drain an abscess of a molar tooth. An Egyptian mandible belonging to the old kingdom (3000 to 2500 B. C.) was similarly drilled[3]. The successful use of these primitive boring and scraping implements of flint to relieve pain which was incident to the formation of an abscess undoubtedly led to an overenthusiasm and the development of metal instruments. In their description of the metal drills and knives, which were used for the purpose of cauterization, the medieval writers took it for granted that it was understood that these tools were adaptations of the early stone implements. Their high regard for the curative value of the cautery may be illustrated by a quotation from Hippocrates[4], who said: "I will give you a strong proof of the humidity of their constitutions. You will find the greater part of the Scythians, and all the Nomades, with marks of the cautery on their shoulders, arms, wrists, breasts, hip-joint, and loins, and that for no other reason but the humidity and flabbiness of their constitution, for they can neither strain with their bows, nor launch the javeline from their shoulder owing to their humidity and atony; but when they are burnt, much of the humidity in their joints is dried up, and they become better braced, better fed, and their joints get into a more suitable condition." The eighty-seventh aphorism of Hippocrates illustrates the high regard for the use of the cautery in his time: "Those diseases which medicines do not cure, iron cures; those which iron cannot cure, fire cures; and those which fire cannot cure, are to be reckoned wholly incurable." [5] Aretaeus, the Cappadocian, gave the following directions for the use of the cautery on the skull: "In the first place we must perforate the bone as far as the diploe, and then use cerates and cataplasms. . . . The exposed bones are

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to be perforated with the trepan if still any small portion prevent its spontaneous removal, . . . and when, having gone through the process of putrefaction and cleansing under the bold treatment of the physician, the wound comes to complete cicatrization, the patients escape from disease." [6]

The wide acceptance of these tools in medical practice no doubt was attributable to the fact that, when heated, they were effective in controlling the bleeding, which was a menace to the operator during the time he was at work. With the advent and use of sutures to control bleeding during the operation, the cautery lost much of its popularity.

It is a singular fact that the "Mound Builders" of Eastern Arkansas probably learned independently to utilize their own commonplace stone implements as cauteries, just as had been done by ancient Egyptians, Chinese, and Greeks. In the beginning, the "Mound Builders" may have first used the drill type of flint for opening abscesses. After the success thus obtained had been observed, a wider application of this and similar instruments was developed.

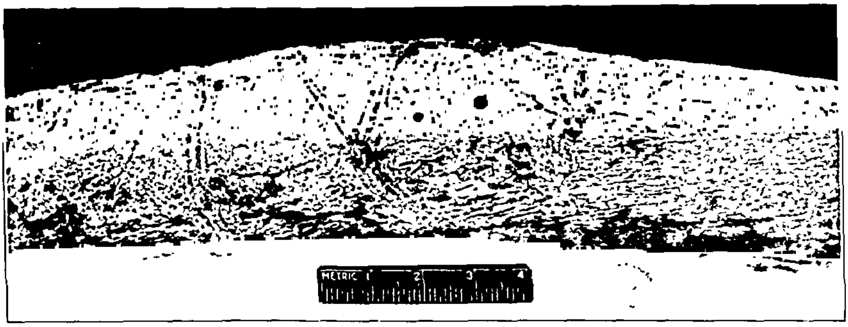

FIG. 1
Tibia with cautery markings.

In a review of the osseous remains of several hundred of these people, the grossly diseased specimens were studied. A number of the pathological specimens of long bones showed grooves which were angular to the long axis of the bone; in some instances, these grooves formed configurations similar to V, X, or Y (Fig. 1). These grooves gave definite evidence that they had been placed there before death, because healing had occurred. If these grooves had been the result of post-mortem marking, there would not have been any evidence of healing. It is known that, at times, the "Mound Builders" of the lower part of the Mississippi Valley denuded the bones of their dead and transported them varying distances for burial in one cache. If these were post-mortem markings which had been the result of some mortuary custom, the normal bones would have shown similar marks. No markings of any nature were found on normal bones. Further evidence to substantiate the idea that these were not the result of mortuary customs is the fact that the bones which were marked in this manner were obtained from fully extended remains, in

which all of the small bones of the hands and feet were in place. Collective remains usually consist only of the long bones, crania, and other large bones of the body.

The specimen shown in Figure 1 may be taken as an example of a number of diseased and injured tibiae which show such grooves or markings. Not a single normal appearing tibia in our collection was marked. In each case, these markings, which had been made with the cautery, almost without exception were placed on the medial aspect of the shaft of the bone, along its subcutaneous surface. The cauterization apparently was started at the anterior border and was extended posteriorly across the entire inner border of the bone. Where a bony prominence offered increased resistance to the posterior progress of the instrument, the groove was deeper anterior to the prominence than it was posterior to the prominence. The grooves were never made deep enough to enter the medullary portion of the bone.

The exception to the rule that cauterization was done only over the diseased portion of the bone was seen in one case. In this case, there was a punctured wound on the lateral aspect of the proximal third of the tibia; there undoubtedly had been a resulting osteomyelitis, with a draining sinus which had extended to the external surface. In this instance, the operator had cauterized the opposite border of the bone.

The femur was infrequently cauterized, and, when this operation

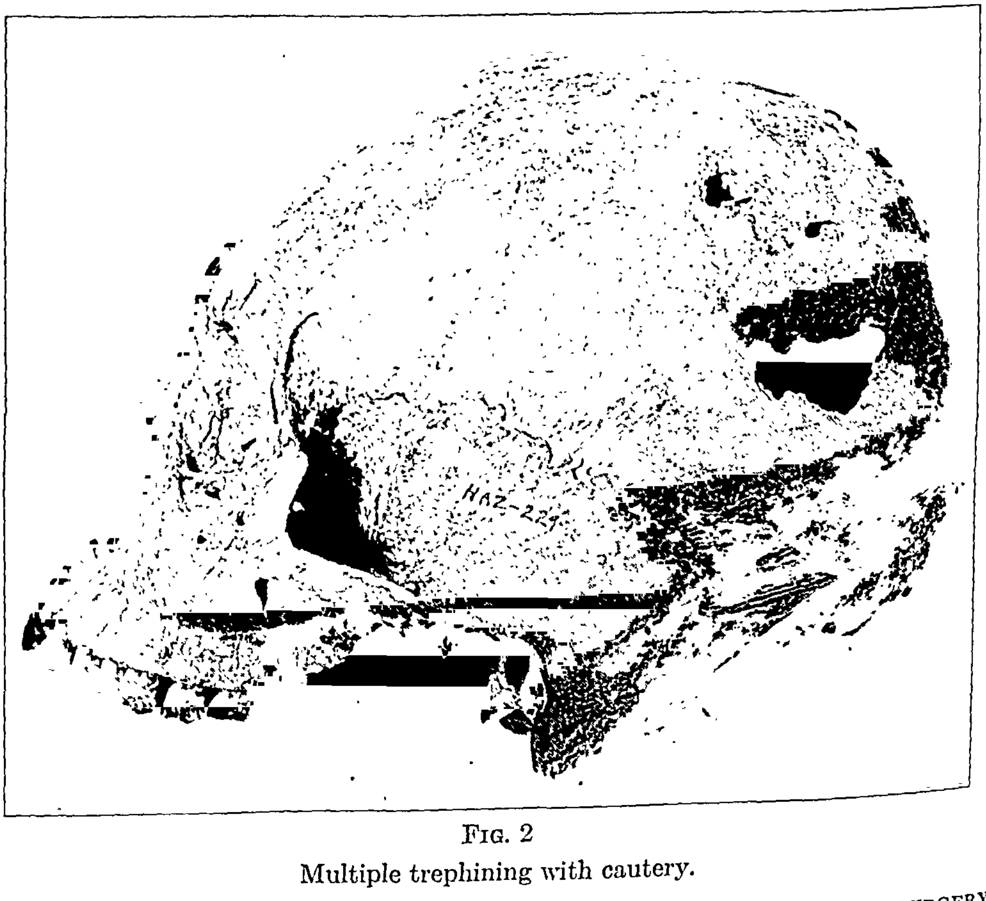

FIG. 2

Multiple trephining with cautery.

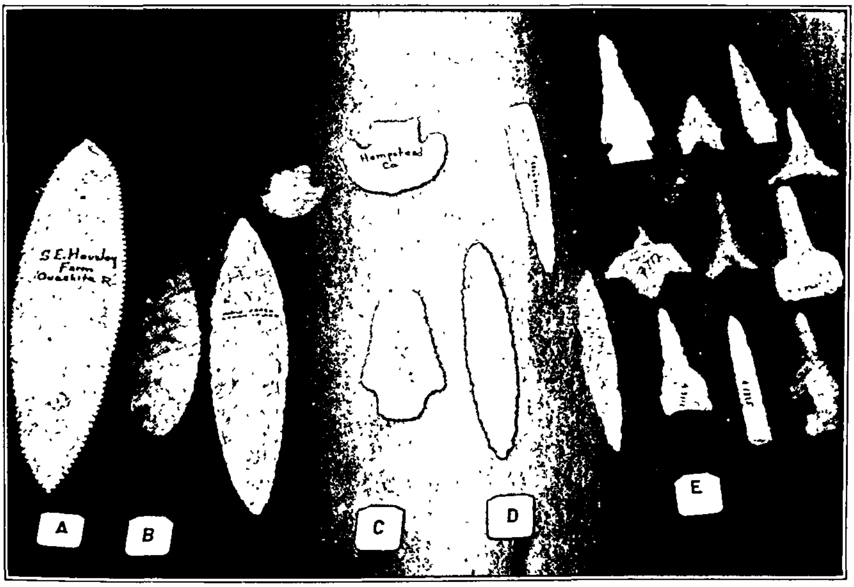

Fig. 3
Stone implements.

was performed on that bone, the cautery was applied to limited sections of the inner border of the distal third of the bone.

In a previous communication, we discussed two skulls which revealed irregular malformations and which we thought at the time might have been examples of trephinement with a cautery or a scraping instrument. Since we have become aware of the fact that some form of a cautery must have been used by these people, we believe that the perforations and scars, which were described and illustrated in our previous article, were the result of the cautery. A photograph of the best example of trephinement with the cautery in our collection is shown in Figure 2.

What were the implements used by these primitive, and now extinct, people for performing these operations? In Figure 3 are shown the stone implements that possibly could have served this purpose, because these people were devoid of metal implements or weapons; In Figure 3, *A* and *B* show types of serrated leaf-shaped knives, which could have been useful either for cutting or scraping bones. In fact, the cauterization of the tibia in Figure 1 was done with an instrument which had a serrated edge, since there are two parallel lines in each groove. Figure 3, *C* shows a type of instrument, commonly known as "blunts" or "scrapers", which would have been useful for scraping large surfaces, as was done in the case of the crania. Figure 3, *D* illustrates long lancelike weapons, which were beveled along the edges. These lances would be very effective instruments for cauterizing bones which were deeply situated. Figure 3, *E* represents a group of instruments which were known as drills or scrapers, and which usually have a haft. Some of them, which have sharp points and are more or less rotary in outline, would be effective

tools for puncturing abscesses or boring holes in bones. The other stones shown in this collection are flattened at the smaller end and have sharpened points, which would make them effective either as drills or scrapers.

COMMENT

In certain districts of Peru have been found many examples of trephinement by means of primitive boring and scraping instruments. Such practices were carried out by precolonial people as far north as Mexico. The use of the cautery and the use of boring or scraping instruments by the primitive people who lived within the continental limits of the United States has been thought to have been limited, if practised at all. We know of no reports of cautery marks, such as the marks which are described in this report, on the long bones of primitive people from any other part of the world. If the cautery had been similarly used for disease of long bones in any other part of the world, we could not give the "Mound Builders" credit for the originality of the idea, unless it could be proved that there had been no contacts between the two races. However, we feel that the adaptation of the primitive stone implements to surgical procedures was a natural consequence in America, as it was in ancient Egypt, Greece, and China.

SUMMARY

An improvised cautery (drills, knives, and scrapers) was used by the "Mound Builders" of Eastern Arkansas on long bones, jaws, and skulls. The indications for use of the cautery seem to have been definite organic disease of the bone, except in the case of trephinement of the skull. The cautery was applied directly to the most easily accessible portion of the affected region.

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THE FATE OF TRANSPLANTED COW'S HORN

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The use of foreign material for internal fixation of fresh or ununited fractures is a well-recognized procedure, but there are conflicting views in regard to the reaction of the tissues to and the ultimate fate of the material used.

Since Fabricious [8], in 1647, and Icart [8], in 1775, employed metal for suture in soft parts and bone, complications have frequently been observed from the use of non-absorbable material. In 1911, Lambotte [2] emphasized the frequency of complications in cases where metal plates had been employed, and stated that it was necessary later to remove them in 46 per cent. of the cases. In 1927, Dahl-Iversen [2] reported osteitis in 28 per cent. of 174 uncomplicated cases where Lane plates had been used. Many surgeons have reported similar discouraging results, where foreign material has been used in bone work, and there is a concensus of opinion that autogenous bone is the best material available for internal fixation. Laboratory workers and clinicians continue to search for material which will have the advantages of the autogenous graft without the necessity of removing bone from the same or another operative field.

Henderson [7] has used beef-bone screws with considerable success, and states that they are well tolerated by the bone, and are gradually but completely absorbed from within six months to a year. Experimental work [5] has demonstrated that boiled beef-bone pegs undergo gradual absorption and are replaced by new living bone.

Mish [1] of Russia is credited with being the first to use horn for internal fixation of fractures. He employed it in three cases, and suggested its general use. Lexer [1], in Germany, at approximately the same time stated that horn was wholly absorbable, non-irritating, and a stimulant to periosteal and endosteal growth. Nine successful cases were reported from his Clinic. In 1929, Dahl-Iversen [3] reported in the German literature his use of horn in the treatment of diaphyseal fractures. He was of the opinion that horn was absorbable and thought that because of this fact the common complications following the use of non-absorbable material would no longer occur. His later experimental work [4] failed to verify this early impression. He placed horn plates in slots made in the cortex across the side of a fracture and observed that the horn was not absorbed but became softer because of the influence of body temperature and fluids. The plates healed in place without reaction. In two cases, osteitis and fistula formation occurred subsequent to operation. At autopsy, in the cases that healed *per primum*, the horn plates were covered with connective tissue and situated in newly formed periosteal bone. There was no bone formation in the groove where the horn plate had contacted the shaft.

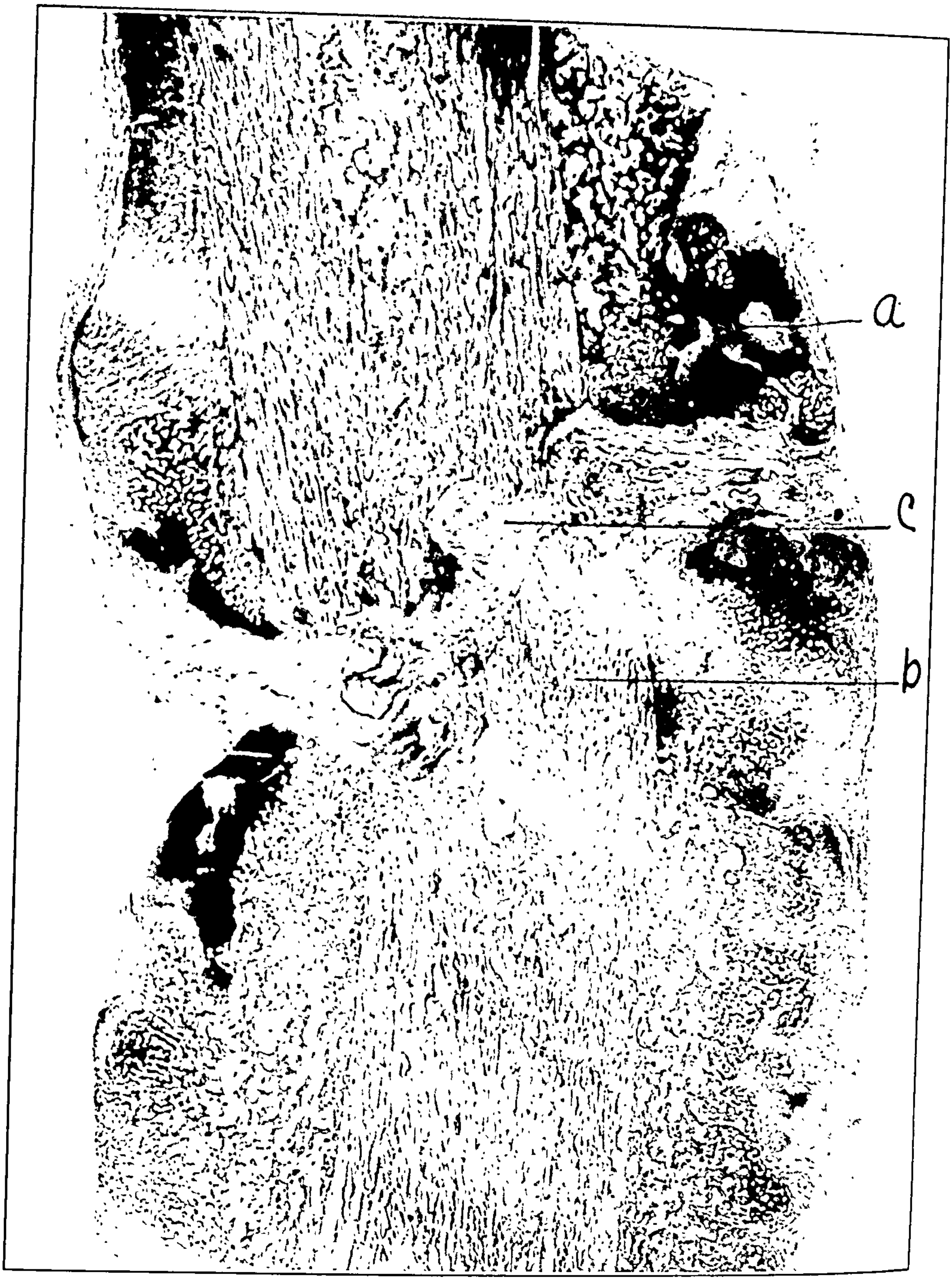

FIG. 1

Control fracture, six weeks after operation.
a: Callus undergoing ossification.
b: Necrotic bone.
c: Fibrous union.

Recently, in this country, the use of horn as a corticomedullary peg has been advocated by Fowler[6] as the method of choice in the treatment of fractures requiring internal fixation. He found experimentally that it underwent "considerable absorption in ninety days".

The lack of unanimity of opinion concerning the fate of horn led us to undertake an experimental study to determine the changes undergone by this tissue when transplanted.

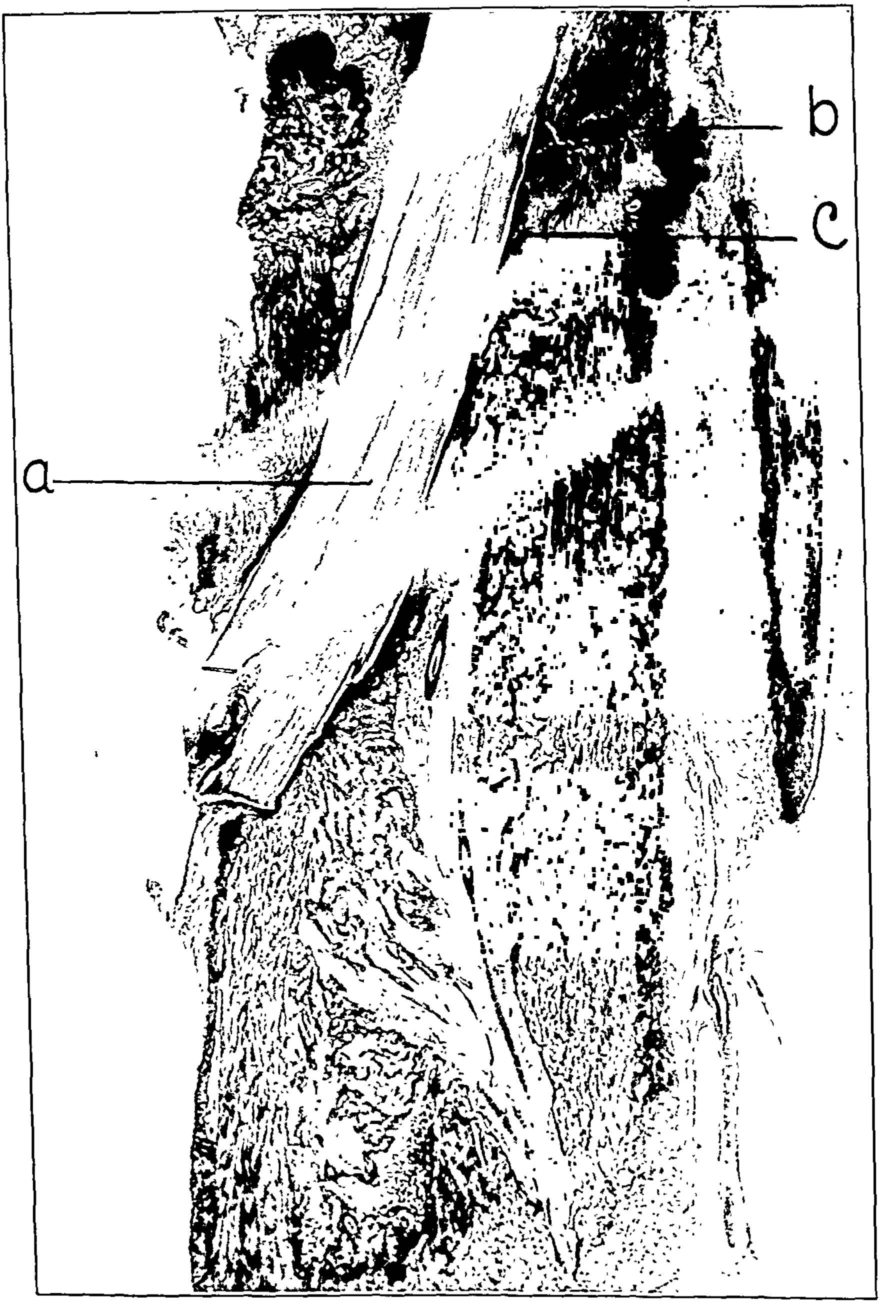

FIG. 2

Fracture six weeks after operation in which horn was used as a corticomedullary graft.

a: Horn.
b: Line of fracture with fibrous union.
c: Fibrous tissue surrounding the horn.

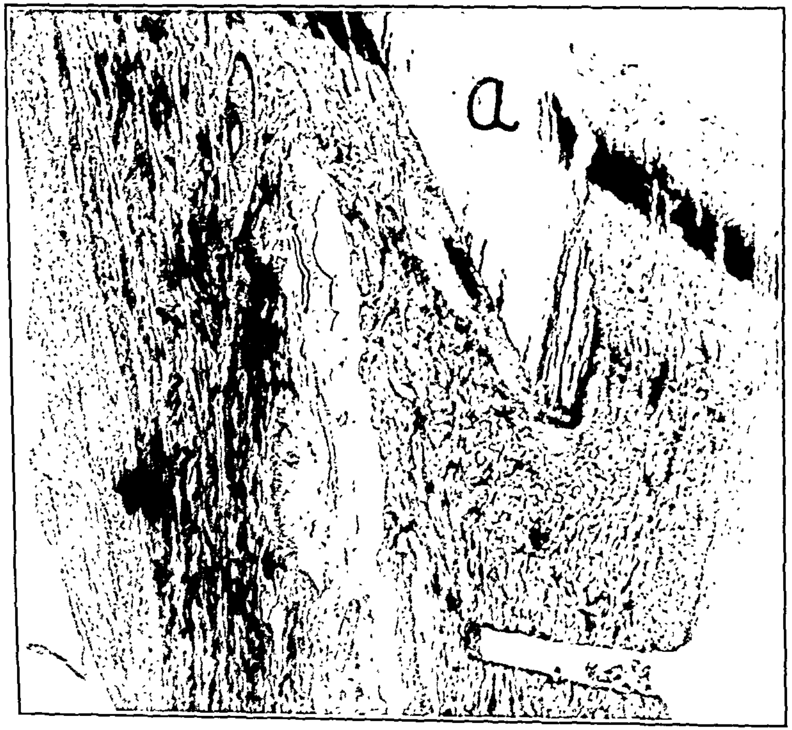

FIG. 3

Fig. 3: Horn transplant seven months after operation in which it was placed as a corticomedullary graft across the line of fracture.
a: Horn separated from the bone by dense fibrous tissue, with no attempt at ossification. Note the clearly defined edge of the horn.

Fig. 4: Horn in medullary cavity of distal fragment seven months after transplantation.
a: Horn.
b: Fibrous tissue. Note the clear-cut borders of the horn.

FIG. 4

The tibiae of dogs were exposed aseptically and fractured transversely in the mid-diaphyseal area. A cortical aperture was made about half an inch proximal to the fracture, and a section of cow's horn was passed through it into the medullary cavity, extending well across the line of fracture. The extremity was then immobilized in a plaster cast, which was allowed to remain in place for at least eight weeks, at which time it was removed. In three cases, a fistula developed at the site of the transplant, nine, ten, and thirteen weeks after healing *per primum*. In spite of the infection, the horn was found to be grossly unchanged when examined at necropsy. The remaining animals were sacrificed at intervals and autopsies were performed; the photomicrographs illustrate the condition of the horn transplants, six and thirty-one weeks after operation. In one experiment, both tibiae were fractured; horn was used for fixation in one leg, while the other was incorporated in plaster without internal fixation. Roentgenograms and gross findings at autopsy revealed no appreciable difference in the amount of callus present on the two sides.

The results of microscopic examination of the tissues are shown in the accompanying photomicrographs.

Figure 1, a section from the tibia of an animal six weeks after operation in which no horn fixation was used, shows callus undergoing ossification. The ends of the fragments show aseptic necrosis with moderate replacement of the dead bone. Lacunar absorption is noted and there is no continuity of bone either endosteally or periosteally.

Figure 2, a photomicrograph six weeks after operation in which horn was employed for fixation, shows a lesser amount of callus. The horn edges are clear-cut, and there is no evidence of absorption. The horn is surrounded by dense fibrous tissue which everywhere separates it from the bone. There is no tendency for the horn to ossify.

In Figures 3 and 4, photomicrographs seven and one-half months after operation, the horn edges are sharply defined, and there is little evidence of absorption and none of substitution of horn by bone. Dense fibrosis is again seen about the horn, separating it from the bone.

SUMMARY

Horn was used as a corticomedullary graft in experimental animals following open operation and fracture to determine its absorbability and its influence on bony union. Microscopic study of cases as late as seven and one-half months after operation revealed little, if any, evidence of absorption of the horn or stimulation of osteogenesis.

CONCLUSIONS

1. Cow's horn is relatively non-absorbable, and the tissues react to it as they would to other non-absorbable material.
2. Cow's horn appears not to stimulate osteogenesis.

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GAIT AND MUSCLE FUNCTION RECORDED BY THE ELECTROBASOGRAPH

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The first description of the electrobasograph was presented in November 1933[1]. Since then, this instrument has been used for making clinical records of gait at the Strong Memorial Hospital. Important experimental work has been conducted in cooperation with one of the large shoe manufacturing companies, and this cooperative effort has led to the accumulation of data pertaining to the functional requirements of shoes in relation to the foot in motion[2]. On the basis of these findings, fundamental changes were made in the design of lasts. The end results of these changes have, for the first time, been expressed in shoes to meet the requirement of balance of the foot in motion. Only through the use of the electrobasograph, was it possible to record imbalance accurately, and to interpret the changes in last design, essential for balance of the foot in association with the differences in heel height required for individual women[2].

More than 800 records of patients and "normal" individuals were made with this original electrobasograph, which was designed and constructed in the gait laboratory. By careful measurements of every line on each record, we have learned that these records were consistent; therefore, the instrument was dependable. Upon this premise, confidence was fostered in the electrobasographic method of recording human locomotion. Moreover, this experience encouraged us to make the improvements in the mechanism as herein described.

It was desirable to have: a greater precision in the instrument, a recorded definition of time in tenths of seconds, improvement in the facility and accuracy of the interpretation of records, and a greater economy in operation of the electrobasograph. The attainment of these indicated improvements was not possible with the limited facilities of our own laboratory.

Through the cooperation of one of the large optical companies, the construction of a precision instrument was begun in January 1933. The original electrobasograph was used as a model and the principles of operation were modified to make possible the improvements mentioned.

In design, this new instrument (Fig. 1) represents the maximum compactness consistent with the requirements enumerated. It was desirable that the records should be proportional to those produced by the original instrument. The present motor speed and the placement of the openings in the aperture plate meet this requirement.

For both convenience and economy of operation, the use of standard 35-millimeter motion-picture film was indicated. The Eastman positive film has been found to have the most suitable emulsion for producing the best records. Figure 2 illustrates an average record of "normal" gait on 35-millimeter motion-picture film. At the top of the film, there is a photographic record of the unit number, date, and the name of the patient; the diagnosis and other information may be added, if desired. The film may be moved forward manually as is necessary in making the photographic record of each legend.

It will be seen that the record has two sets of lines which are at right angles to each other. The lines parallel to the width of the film indicate time recorded in seconds and tenths of seconds. One second of time is indicated by the space between the heavy lines which are separated by ten equal spaces. The lines parallel to the length of the film are the recorded duration of weight-bearing on the respective points of the functional osseous tripod of each foot, as expressed through the medium of the subject's shoes.

These six lines are the result of the exposure of a photographic emulsion by light which passes through corresponding openings in the aperture plate. Three additional slits in the aperture plate were provided for recording muscle function, or the use of crutches, simultaneously with gait records. In brief, nine vertical lines may be recorded on the film.

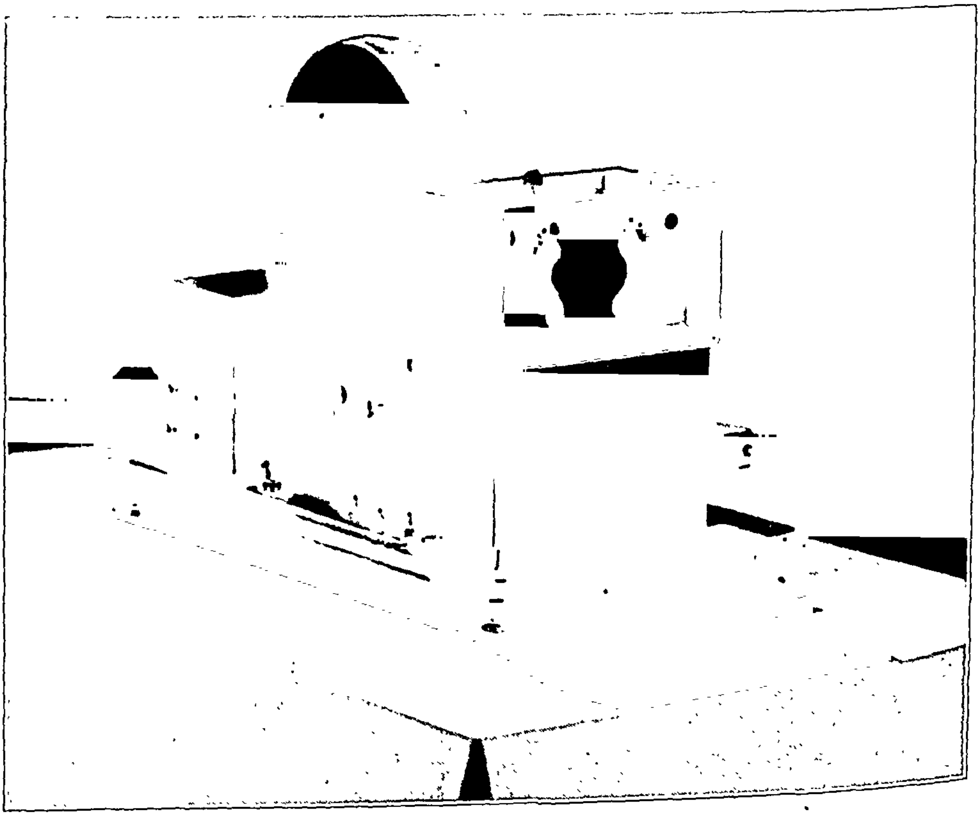

FIG. 1

The 35-millimeter electrobasograph which makes photographic records of the way a subject walks.

The timing in seconds and tenths of seconds is, therefore, applied to all alike. A sharp image of all lines recording gait, muscle function, etc., is assured by an adjustable-friction film gate which causes the film to be held straight at the aperture plate where exposure takes place.

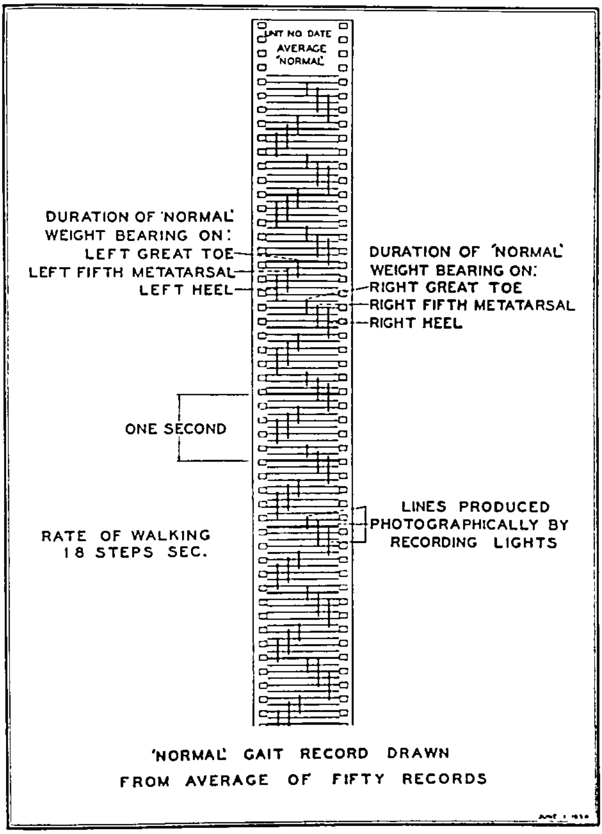

FIG. 2

The method of making the record (Fig. 4) is identical with that described in the first paper which presented the electro-basograph. Reloading with new film is made easy by the automatic release of the film gate when the film chamber is opened. Rapid and accurate threading of the film has been made possible by backward rotation of the sprocket.

A special device is provided to notch the edges of the film at the end of each record, so that the records may be identified in the dark room for cutting before developing. An audible warning signal prevents the possibility of continuing to make records after all the unexposed film has been used. The total number of feet of film used in a given time is shown by the footage indicator which may be turned back to zero by a key. An additional feature provides for making a number of records up to twenty-five, after which they may be removed from the instrument in a light-proof chamber for developing. The intermittent illumination of a red light is a visual indication that the machine is in operation. Failure of illumination of any bulb in the instrument is instantly visible; thereby preventing errors. Moreover, all of

Name.....
Unit No. .....

Normal Weight-Bearing Time
Average Rate of 1.8 Steps/Second

Date		
Record No.		
Left Heel	.444	
Left Met.	.525	
L. Gt. Toe	.541	
R. Gt. Toe	.540	
Right Met.	.502	
Right Heel	.469	
Time on L. Foot	.735	
Time on R. Foot	.668	
R. Toe-L. Heel Dbl. Wgt	.108	
L. Toe-R. Heel Dbl. Wgt	.101	
Steps Per Second		

FIG. 3

Showing record blank used in tabulating weight-bearing time. Figures given are the average of more than 1,000 records of "normal" individuals.

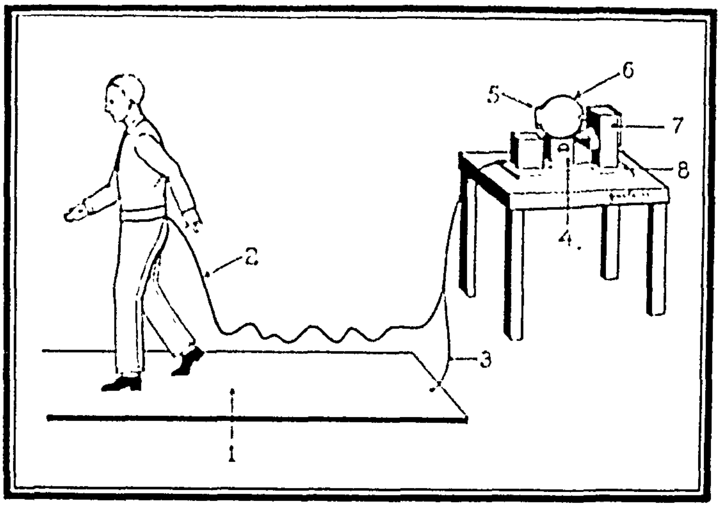

FIG. 4

Method of making records with the new 35-millimeter electrobasograph: *1*, metal surface on floor; *2*, wires from metal contacts on shoes; *3*, ground circuit; *4*, take-up film chamber; *5*, electrobasograph; *6*, film magazine; *7*, light magazine; *8*, base.

these lamps are readily accessible without the use of tools

The mechanical improvements enumerated were immediately reflected in the records produced by the new 35-millimeter electrobasograph. Greater convenience in handling and filing the records was made possible by their reduction to one-half the former size.

The foregoing description of the mechanism is essential to an understanding of the application of the 35-millimeter electrobasograph to the study of human locomotion. Without this knowledge, one cannot adequately grasp the significance of records revealing the correlation of gait and the function of the muscles which control the foot.

Our present knowledge of muscle function is based upon the mechanics of related structures, as observed in the cadaver, or by the behavior of a member under the influence of the voluntary contraction of one or more muscles. Such studies are either purely mechanical, as related to an inanimate object, or they are static observations of the interrelated muscle function which makes it possible for a person to walk. For these reasons, it is believed that the essential knowledge relevant to muscle function in relation to gait has not been provided by such methods of study.

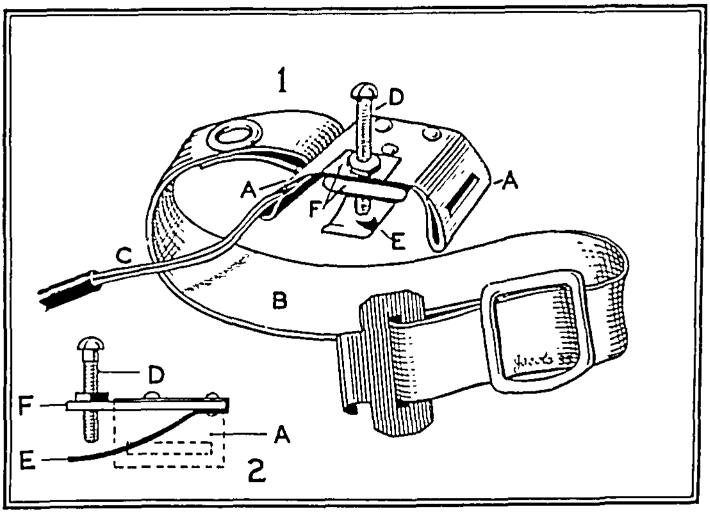

FIG. 5

A contact for recording muscle function (usefulness not defined beyond the limits expressed in this paper): *A*, flanges; *B*, adjustable-tension rubber band with clip for flange; *F*, base through which adjustable screw *D* passes; *E* spring which, when elevated by tendon, contacts screw *D* and completes circuit which is carried to lamp in electrobasograph by wires *C*.

It was, therefore, indicated that an effort

should be made to record muscle function in terms of duration and sequence of contraction during the act of normal walking. Moreover, it was desirable to proceed in a manner which would accurately correlate the duration of muscular contraction with the established "normal" gait record.

Accordingly, our first thoughts were directed to the development of a method that would provide the required data with reference to major muscles which control the function of the foot during the act of walking. The following procedure was, therefore, carried out with respect to the tibialis anterior, the peronei, the gastrocnemius and soleus, the extensor digitorum communis, and tibialis posterior. The tendons of these respective muscles were used as the medium for determining the sequence and duration of contraction as related to the sequence of weight-bearing of the respective functional areas of each foot, as compared with the normal sequence of weight bearing.

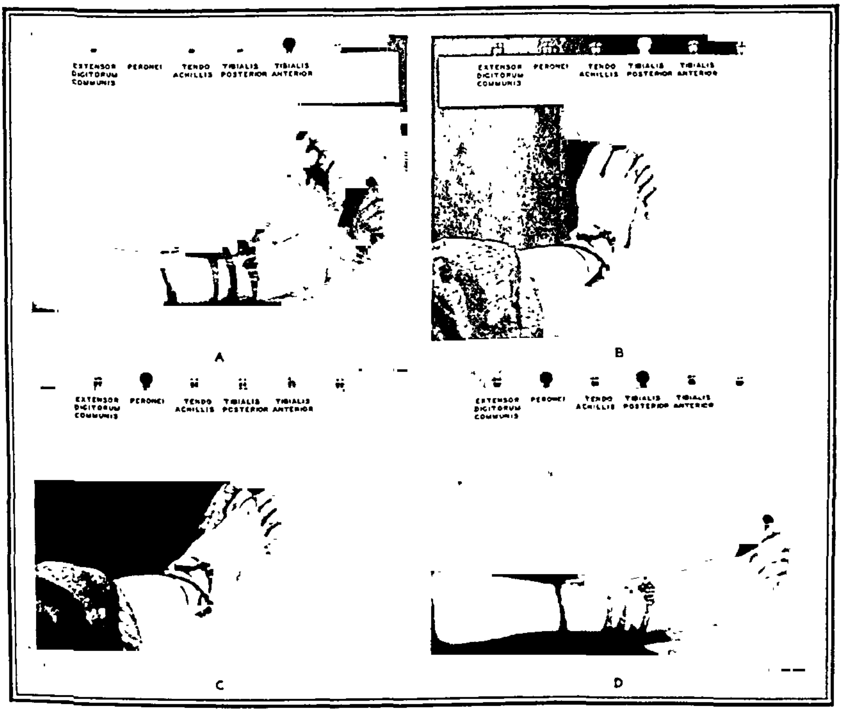

FIG. 6

Showing contacts placed over the tendons.

A: From the neutral position, the foot was dorsiflexed and the forefoot held in varus by contraction of only the tibialis anterior.

B: Heel in varus, forefoot neutral, by voluntary contraction of only the tibialis posterior.

C: Heel and forefoot in valgus, from neutral position by voluntary contraction of only the peronei.

D: Foot in plantar flexion, from neutral position, by an equal degree of voluntary contraction of both the tibialis posterior and the peronei.

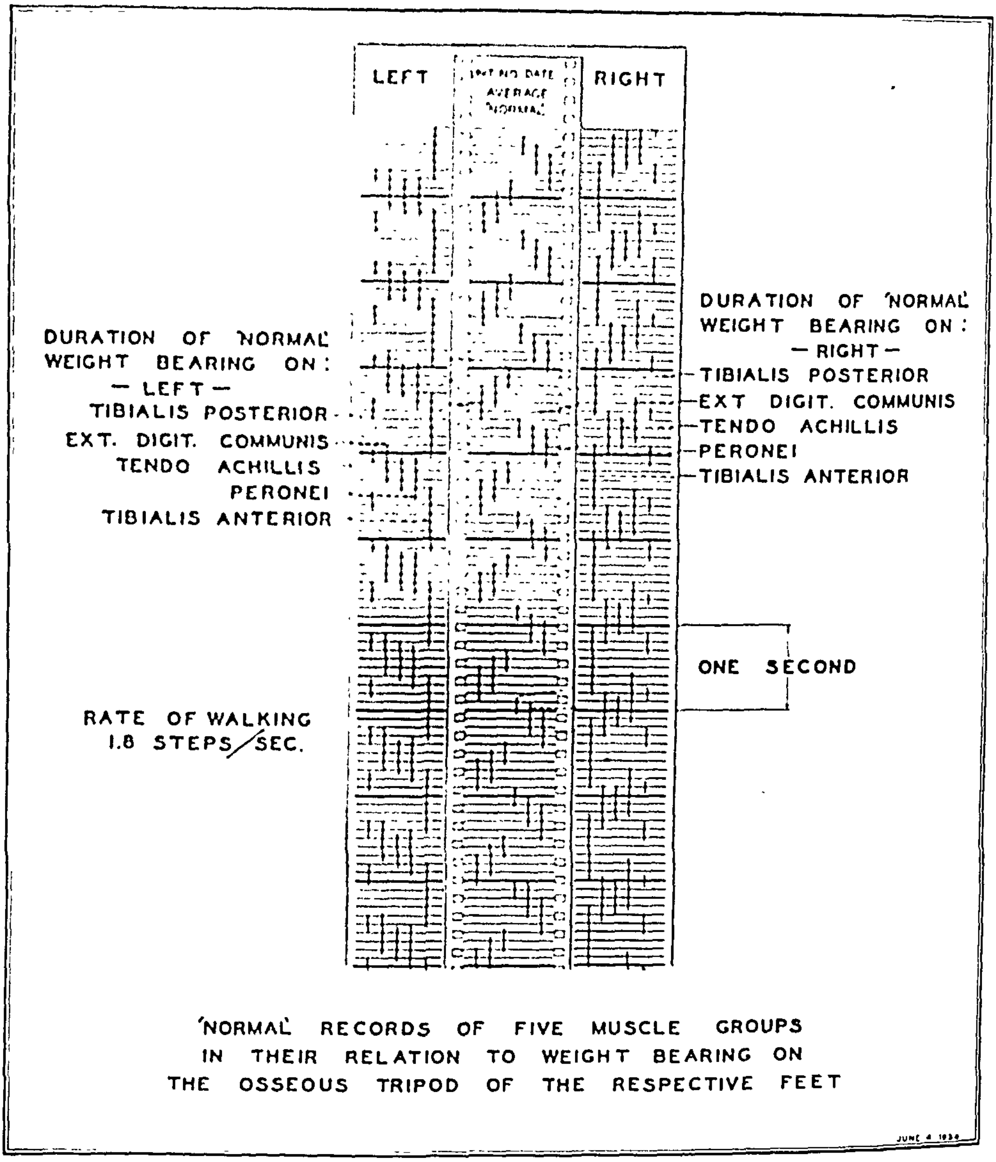

Fig. 7

These records reveal the rhythm in sequence and duration of contraction of the respective normal muscles in relation to the duration of weight-bearing on the respective functional areas of each foot during the act of "normal" walking at the rate of 1.8 steps per second.

It is evident that the method required a mechanism upon which the influence of the contracting muscle would, through the elevation of its tendon, activate an incandescent lamp. Repeated experiments led to the design of such a mechanism as is illustrated in Figure 5. The flanges (*A*) elevate the spring (*E*) above the surface overlying the tendon. The elastic band (*B*) is adjustable for tension sufficient to hold the mechanism in fixed position, lateral displacement being prevented by the flanges (*A*).

A number of such contacts were simultaneously placed over the respective tendons as shown in Figure 6. No bulbs were illuminated when the foot rested in the neutral position. Voluntary contraction of only the tibialis anterior (Fig. 6, *A*) held the foot in dorsiflexion with varus of the forefoot. This caused illumination of only the corresponding bulb as il-

lustrated. Voluntary contraction of only the tibialis posterior changed the neutral position of the foot to one of varus without dorsiflexion. This was accompanied by illumination of only the corresponding bulb (Fig. 6, *B*). Isolated voluntary contraction of the peronei held the foot in valgus without dorsiflexion of the forefoot (Fig. 6, *C*). Simultaneous voluntary contraction of the tibialis posterior and the peronei changed the neutral position of the foot to one of plantar flexion. Both corresponding bulbs were illuminated (Fig. 6, *D*). Similar experiments were made to reveal the contraction of the extensor digitorum communis.

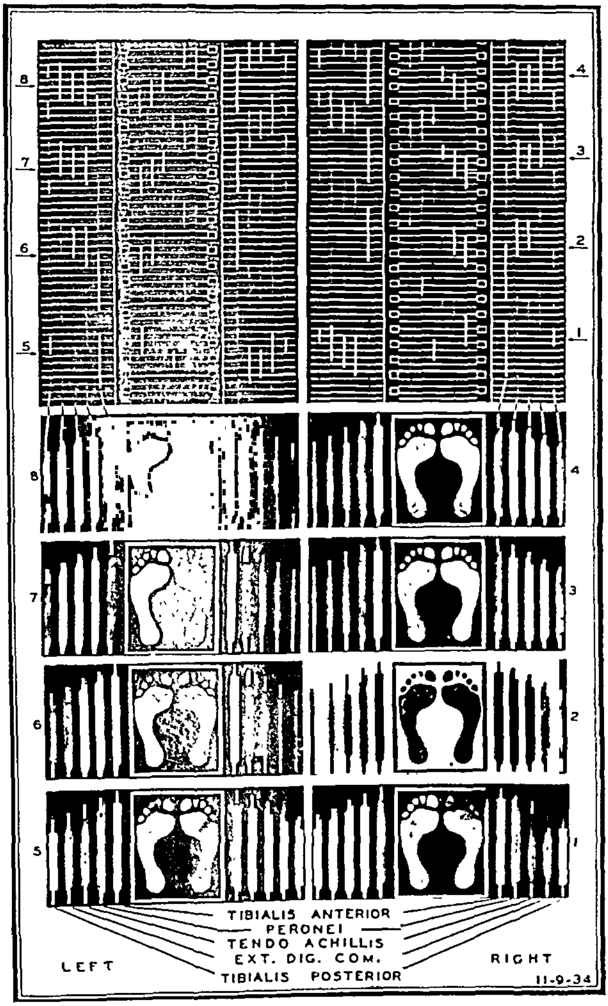

FIG. 8

The visualization of muscle function in eight phases of a single step, correlated with the sequence of weight-bearing on the respective functional areas of each foot.

Such evidence of the contraction of the gastrocnemius and soleus could not be obtained with the non-weight-bearing foot. Plantar flexion is apparently initiated by the tibialis posterior and the peronei. Evidence thus far indicates that contraction of the gastrocnemius and soleus follows under the influence of superincumbent weight. *It is, therefore, evident that these experiments proved the absence of a current except when the circuit was closed by the elevation of a tendon due to the contraction of one or more muscles.*

This having been determined, records of muscle function were then made simultaneously with records of gait. The procedure for making the electrobasographic gait records was the same as has been described in papers previously published. In addition, the following method was applied for recording the sequence and duration of contraction of the muscles in successive normal individuals while walking.

The muscle contacts were placed over the right and left tibialis anterior muscles respectively. Repeated tests were made to prove that the contact was closed only when the tendon was elevated by contraction of the respective muscles. Under these conditions, several records were made of the same and different normal individuals during the act of walking. This procedure was repeated with respect to the other four muscles mentioned. The sequence and duration of muscle contraction were finally determined by averaging the records made on each muscle in relation to the average rate of walking, as determined by the gait record of each person.

The rhythm in sequence and duration of contraction of these muscles in relation to the duration of weight-bearing time on the three functional divisions of each foot is revealed in Figure 7. A complete mathematical expression of the records of muscle function is in preparation. A subsequent paper will correlate this with the normal gait record.

A better understanding of Figure 7 may be gained by a study of Figure 8. This illustration was made by interpreting Figure 7 in terms of eight phases of a single step, as indicated in the upper portion from right to left. For visualization and ease of understanding, a section, including one step and the corresponding muscle function, was accurately copied from the record. This section of the record was fixed on a circular drum which was driven by an electric motor. This drum was mechanically and electrically connected with a transillumination box which was wired with electric bulbs in compartments corresponding to the heel, midfoot, and forefoot of each foot. Glass tubes, fitted with electric bulbs, were arranged to represent the five muscles in the order named. The sequence and duration of illumination of each set of bulbs in this entire mechanism was activated by the record on the revolving drum. The rate of rotation of this drum was made variable by rheostat control; it could be stopped by a switch at any phase of the step. It was, therefore, possible to make photographs of eight successive phases of a single step, with relation to weight-bearing on the three major functional areas of each foot. By so doing, we were able to reveal the muscles which were contracting in each respective phase of the step. The visualization of such muscle function was, therefore, made with relation to the sequence of weight-bearing on each foot.

The plantar surface, as revealed by the divisions corresponding to the functional areas of each foot, is represented on the transillumination box, illustrated in the lower portion of Figure 8. The glass tubes, representing the five muscles, are arranged on the right and left sides of the transillumination box. The record of combined gait and muscle function is shown in the upper portion of Figure 8. This is a diagrammatic arrangement to reveal eight phases of a single step.

The period of double weight-bearing is revealed in Phase 1. Weight is being transferred from the left forefoot to the right heel. All muscles of the left leg are contracting except the tibialis anterior. On the right,

only the tibialis anterior and tibialis posterior are in contraction. Evidence of contraction of the tibialis posterior at this phase of the step accounts for the common observation of wear on the shoe heel, lateral to the midline. The arrow in Phase 1 of the gait record indicates a line which passes through the point of double weight-bearing on the left forefoot and the right heel. It will be seen that this line also passes through the lines indicating the contraction of the muscles mentioned.

In Phase 2, the left foot has entered the swing phase. Here it is normally held in dorsiflexion by contraction of the tibialis anterior. The right foot has received weight from the heel onto the area corresponding to the midtarsal region. The right tibialis anterior, the peronei, and the tendo achillis are in contraction; the contraction of the tibialis posterior has ceased. Referring to the gait record, a line passing through Phase 2 at the level of the arrow crosses the lines indicating weight-bearing on the right heel and midtarsal areas. It also crosses the lines indicating contraction of the tibialis anterior, the gastrocnemius-soleus (tendo achillis), and the peronei. This line passes through only the line indicating contraction of the left tibialis anterior, the left foot being in the swing phase.

In Phase 3, weight has been transmitted forward so that the entire plantar surface of the right foot is under the influence of superincumbent weight. Contraction of the peronei, the gastrocnemius-soleus (tendo achillis), and the extensor digitorum communis is indicated by the illumination of the tubes. The right tibialis posterior muscle is not in contraction. The left foot is still in the swing phase. The left tibialis anterior alone is in contraction.

Phase 4 finds the left foot still in the non-weight-bearing position under the influence of the contraction of only the tibialis anterior which holds it in dorsiflexion. The left forefoot is still held in varus as it swings forward. It is at this phase that the foot is being lowered prior to the reception of weight on the left heel in the next phase of the step. The right foot reveals elevation of the heel with transference of the full body weight onto the midtarsal and forefoot areas, principally the latter. This change has occurred under the influence of the continuation of the contraction of the right peronei, the tendo achillis, and the extensor digitorum communis. The gastrocnemius and soleus through the tendo achillis have exerted the maximum effort in the elevation of the heel under the influence of the entire body weight. The peronei and the extensor digitorum communis have effected a position of valgus of the foot which is essential for normal transference of the weight from the lateral to the medial side of the forefoot. In addition to this, the extensor digitorum communis has served the principal function of opposing plantar flexion of the toes in this phase of the step.

Phase 5 reestablishes the period of double weight-bearing. Weight is being transferred from the right great toe to the left heel. The phenomena relevant to contracting muscles are the same as described for the first phase, except that they are reversed to opposite sides.

In Phases 6, 7, and 8, the facts are the same as related for Phases 2, 3, and 4, except that all functioning structures are reversed to the opposite sides.

SUMMARY

1. The sequence and duration of contraction of the tibialis anterior, the peronei, the gastrocnemius and soleus (tendo achillis), the extensor digitorum communis, and tibialis posterior have been recorded during the act of walking.

2. All records have been timed accurately to within hundredths of a second.

3. With this precision, the records of muscle function have been simultaneously correlated with the sequence and duration of the weight-bearing areas of the feet during the act of walking.

4. The record of "normal" gait presented herewith is based upon the results obtained from the making of more than 1,000 records of human locomotion by the electrobasographic method.

The 35-millimeter electrobasograph was provided through the cooperation of Mr. Herbert Eisenhart. Continuation of the association with Mr. William Washburn has made possible the further work, reported herein, on requirements of the shoe in relation to the foot in motion.

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1. Schwartz, R. P., Heath, A. L., and Wright, J. N.: Electrobasographic Method of Recording Gait. Arch. Surg., XXVII, 926, 1933.
2. Schwartz, R. P., Heath, A. L., and Misiek, William: The Influence of the Shoe on Gait as Recorded by the Electrobasograph and Slow-Motion Moving Pictures. J. Bone and Joint Surg., XVII, 406, Apr. 1935.

A METHOD FOR MEASURING AND RECORDING JOINT FUNCTION

From the Fracture Clinic of the Massachusetts General Hospital

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Committee on Joint Measurement

When the Fracture Clinic at the Massachusetts General Hospital began end-result studies, the need of a standard system of measurement of joint function became evident. Fractures lend themselves well to a follow-up system, because their end results can be rated not only functionally, but anatomically and economically as well.

Individual methods of measuring and recording joint function vary considerably and, when grouped together, may be confusing. Therefore, to be of value, records must be uniform and all members of a clinic should use the same nomenclature when recording their findings.

This system has been made as simple as possible and does not pretend to cover the finer details of joint measurement. It is the result of ten years' trial, plus helpful suggestions received from twenty-five members of the Fracture Committee of the American College of Surgeons to whom this method was submitted for comment.

We hope that this outline will prove useful and, if adopted, will simplify the comparison of statistics compiled by different clinics.

GENERAL PRINCIPLES

1. All motions should be measured by degrees from a neutral point of zero.

2. The neutral point from which the motion is measured must be defined.

3. It is always worth while to mention the comparative motions in the joint of the opposite limb.

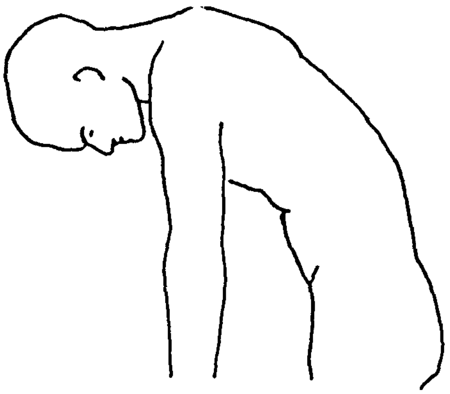
4. Angles should be measured with a goniometer or protractor.

5. Motions of joints above and below the affected part should be measured.

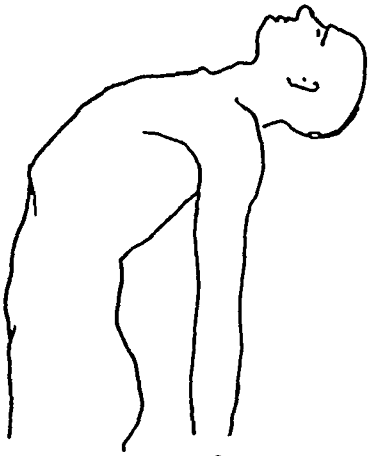
SPINE

Neutral position cannot be defined.

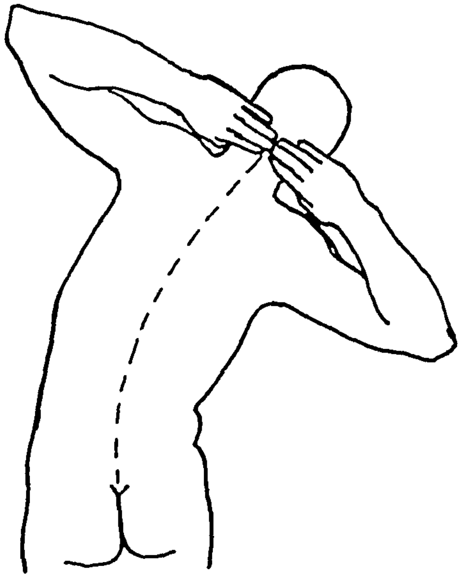
1. Forward bending—this motion cannot be measured accurately in degrees, but should be compared with the probable normal for the age of the patient. It should be noted whether the lumbar spine flattens or reverses itself. Motions should be carried out in both sitting and standing positions.
2. Extension—it should be noted to what degree the dorsal and lumbar curves change.
3. Lateral bending—right and left.
4. Rotation with pelvis fixed—right and left, comparing angle made by the shoulders with pelvis.



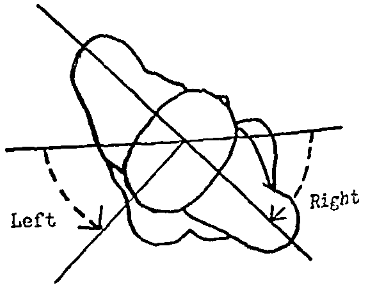
1
Forward Bending



2
Extension



3
Lateral Bending

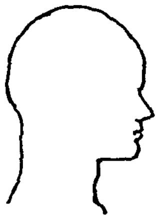


4
Rotation

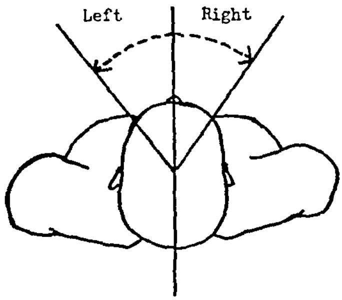
NECK

Neutral position is with head up and chin in.

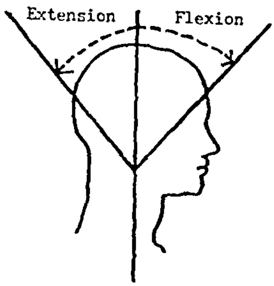
1. Rotation—right and left.
2. Flexion.
3. Extension.
4. Lateral bending—right and left.



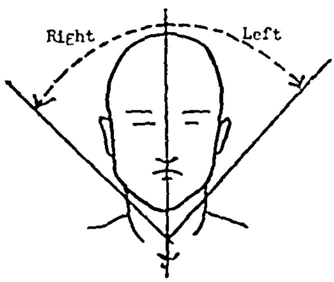
Neutral



1
Rotation



2+3
Flexion
and
Extension

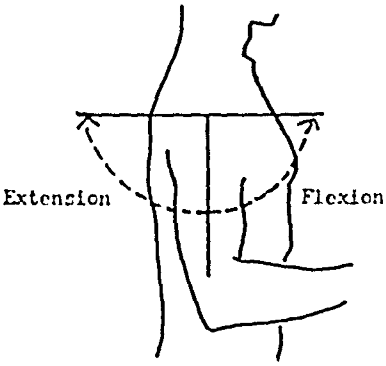


4
Lateral Bending

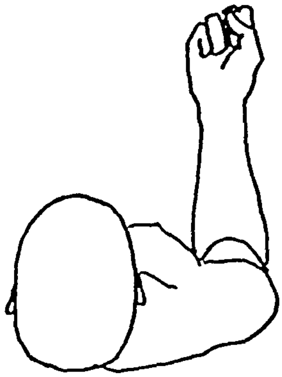
SHOULDER

Neutral position is arm to side, elbow flexed to 90 degrees, forearm pointing forward.

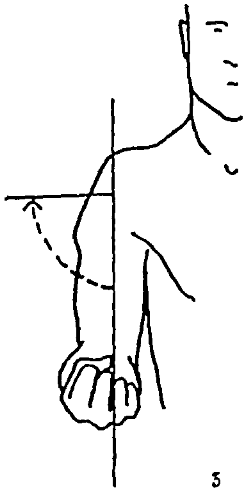
1. Flexion.
2. Extension.
3. Abduction—maximum 90 degrees.
4. Rotation in abduction.
5. Rotation in neutral (arm behind back to test extreme internal rotation—compared with opposite side).
6. Elevation—compared with opposite side and measured in number of degrees. (This is shoulder-girdle motion as compared with items 1 to 5 which are true humeroscapular motions.)



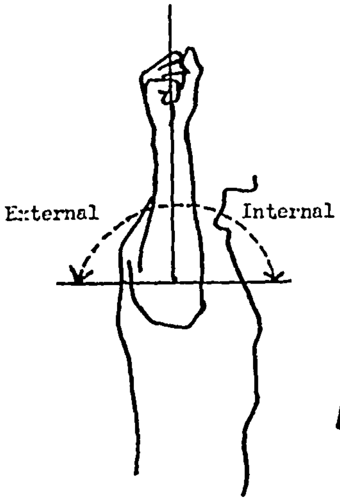
1 + 2
Flexion and Extension



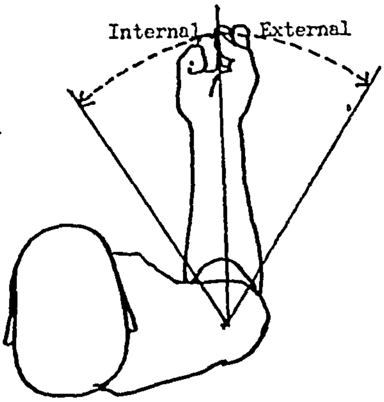
Neutral



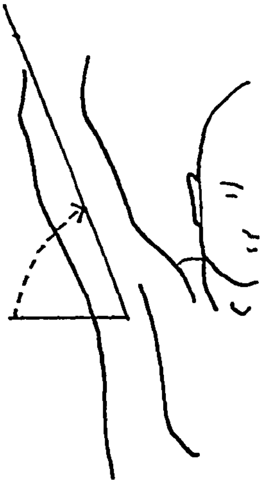
3
Abduction



4
Rotation in Abduction



5
Rotation in Neutral



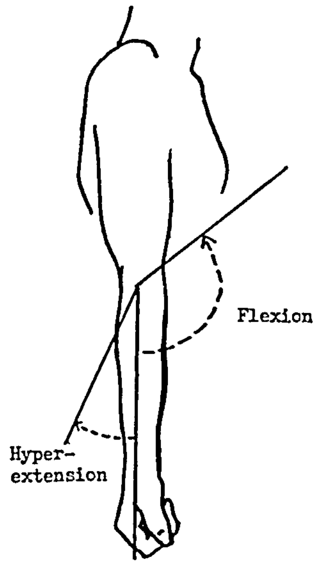
6
Elevation

ELBOW

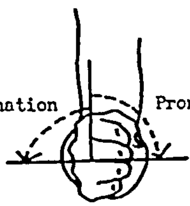
Neutral position is with forearm in extension.

1. Flexion—measured from complete extension, the neutral point.
2. Hyperextension—measured in degrees as compared with the opposite elbow.
3. Supination from a neutral point—which is midposition between pronation and supination.
4. Pronation—elbow must be fixed at side in 90 degrees of flexion.
5. When there is loss of complete extension, this loss should be recorded in degrees of permanent flexion.

Neutral



1 + 2
Flexion and Hyper-extension



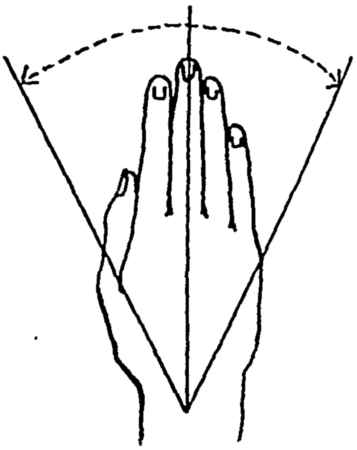
3 + 4
Supination and Pronation

WRIST

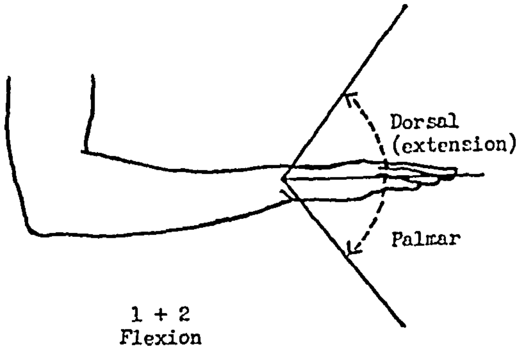
Neutral position is with hand in line with forearm with palm down.

1. Dorsiflexion (extension).
2. Palmar flexion.
3. Ulnar deviation.
4. Radial deviation.
5. Pronation } to be noted as described under ELBOW.
6. Supination }


Neutral



3 + 4
Deviation



1 + 2
Flexion

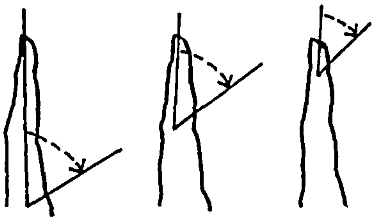
FINGERS

Neutral position is with fingers in extension.

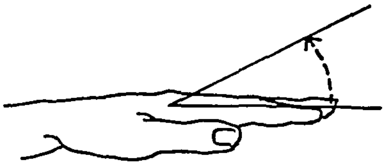
1. All motions are in flexion either in the metacarpophalangeal or interphalangeal joints.
2. Hyperextension should be noted if present.
3. Test should be made for increased lateral mobility.

FINGERS

Neutral



1
Flexion

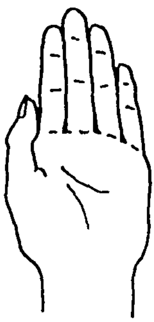


2
Hyperextension

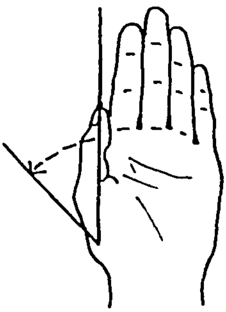
THUMB

Neutral position is with thumb alongside the forefinger and extended.

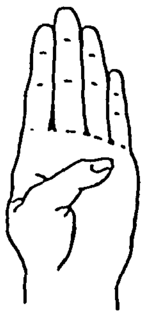
1. Abduction—measured by the angle that the thumb makes with the forefinger.
2. Flexion—measured the same as for the fingers.
3. Opposition—cannot be measured in degrees; it should be noted how far thumb comes across the palm.



Neutral



1
Abduction



3
Opposition

HIP

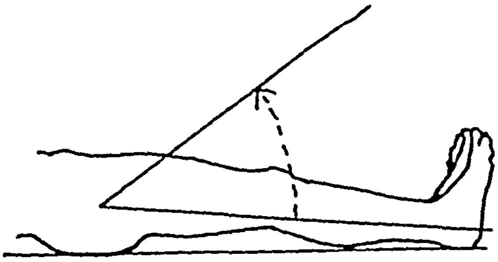
Neutral position is with hip in extension, patella pointing upward.

1. Flexion measured with the knee bent. Opposite thigh must remain in neutral.

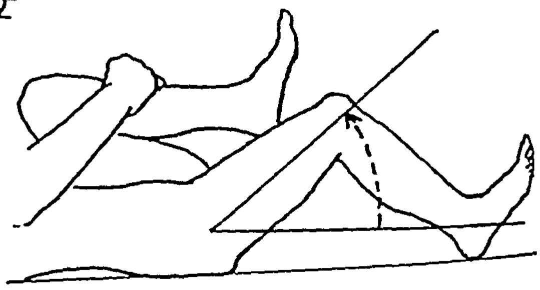
1-A. To test permanent flexion, the opposite thigh must be flexed, so as to flatten the lumbar spine and to fix the pelvis.

2. Hyperextension—neutral, the same as for flexion, but with the patient lying prone with opposite thigh over the end of table at an angle of 90 degrees.

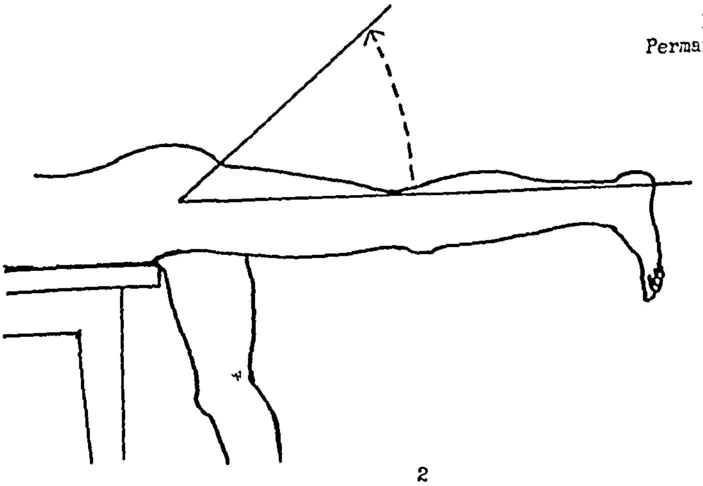
Neutral



1
Flexion



1 A
Permanent Flexion



2
Hyperextension

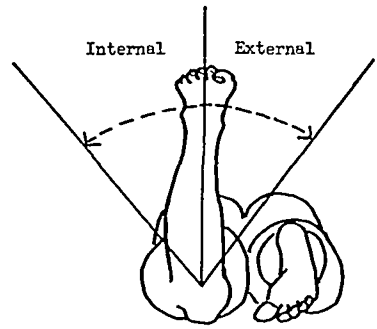
HIP (*Continued*)

3. Abduction—measured from a line which forms an angle of 90 degrees with a line joining the anterior-superior spines.

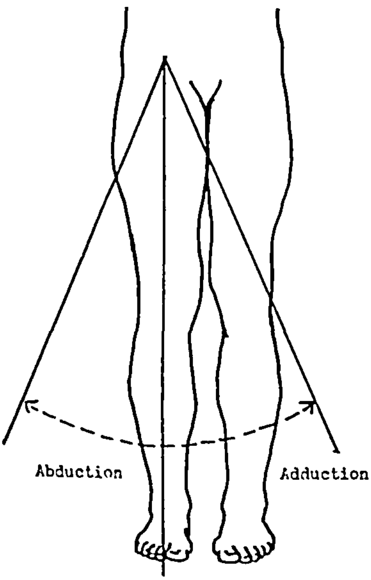
4. Adduction—the same.

5. Rotation (external and internal) in extension. Measurement should be made with patient prone and knee flexed to 90 degrees.

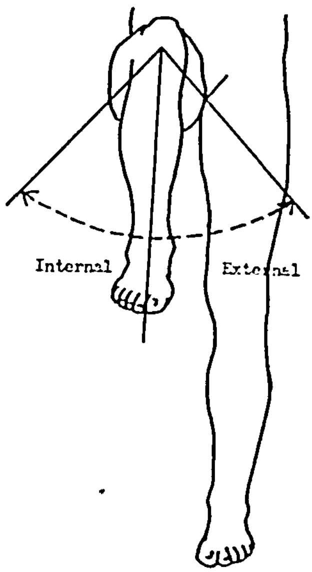
6. Rotation (external and internal) in flexion. Measurement should be made with patient on back with knee and thigh flexed to 90 degrees.



5
Rotation in
Extension



3 + 4
Abduction and Adduction



6
Rotation in flexion

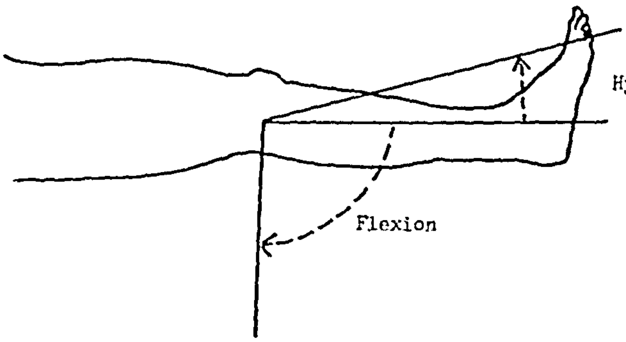
KNEE

Neutral position is complete extension.

1. Flexion—measured in degrees from complete extension.
2. Hyperextension.
3. Anteroposterior stability should be tested with the knee in 90 degrees of flexion.

   Lateral stability should be tested with the knee in complete extension.
4. When there is loss of complete extension, it should be recorded in degrees of permanent flexion.

Neutral



1 + 2
Flexion and Hyperextension

ANKLE

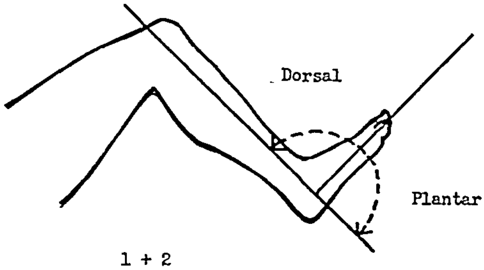
Neutral position is with the outer border of the foot at 90 degrees with the leg and in neutral as regards inversion and eversion.

1. Dorsiflexion should be tested with the foot in inversion.

   Measurements should be compared with knee flexed and with knee in extension, to rule out tight calf muscles.
2. Plantar flexion.

ANKLE

Neutral



1 + 2
Flexion

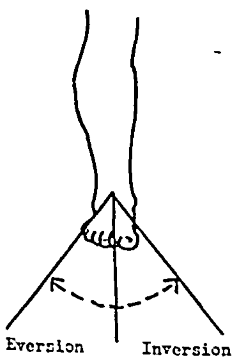
FOOT

Neutral position cannot be defined.

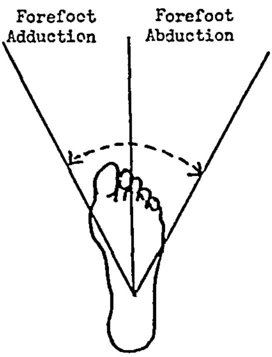
1. Subastragalar motion is inversion and eversion.
2. Mediotarsal joints (forefoot adduction and abduction) tested passively with the os calcis held in neutral.
3. Metatarsophalangeal joints—particularly important in the great toe.
4. Interphalangeal joints—tested in flexion and extension, and for increased lateral mobility.

Motions cannot be accurately measured in degrees.

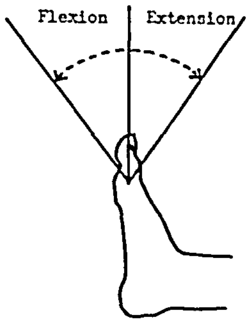
Mention should be made as to whether motion is abnormally free or restricted, and in which direction there is restriction.



1
Subastragalar



2
Mediotarsal



3
Metatarso-phalangeal

HEMIHYPERTROPHY AND HEMIATROPHY

Congenital Total Unilateral Somatic Asymmetry*

BY CHARLES W. PEABODY, M.D., DETROIT, MICHIGAN

From the Sigma Gamma Clinic and Hospital School for Crippled Children, Detroit

At the outset, it should be specified that the subject matter of this paper concerns itself only with what may be more specifically and suggestively described as congenital total somatic asymmetry. In the fairly exhaustive analysis of the world's literature since 1900, which was involved in this study of the subject, a very considerable number of references with the above titles were found to deal with a variation in the size of one member only, or with localized gigantism of a part or parts of a member. However, partial gigantism may be an accompaniment of total somatic asymmetry, as illustrated in one of the cases reported herewith.

Until recent years, the occasional reports of this condition often referred to it as the rarest of congenital anomalies. In 1927, Arnold Gesell, a neuropsychiatrist published the first significant review and discussion of hemihypertrophy. In this article he made a supplementary report of a case previously described in 1921 and added a second case. Including these two cases, he found that the number of cases of congenital total unilateral hemihypertrophy reported throughout the world up to 1927 was fifty-three. The writer's search has disclosed only three cases of hemiatrophy that were also total unilateral in type. Since then, references have become much more frequent, and, although in the main still consisting only of single case reports, these articles occasionally present more than one case. One observer reported four cases and another, six. Since 1927, a total of thirty-six cases have been reported under the classification of hemihypertrophy and have been found to be total unilateral. In addition, there has been recorded one case that seems to indicate an authentic hemiatrophy of this distribution. Altogether, the literature seems to contain a grand total of ninety-three cases of congenital total unilateral somatic asymmetry, and to these the writer now adds the following six cases of his own observation, with description and comments thereon.

Case 1. A girl, aged thirteen, was first observed by the author five years ago. The clinic record of observations made three years previously noted diffuse bilateral dermal angiomata and total unilateral right hemiatrophy. The height and weight data were not obtained, but photographs suggested average development for age on the smaller side, and on the larger side a girth rather greater in proportion to length. When seen by the writer three years later, her measurements on both sides fell within normal limits for the age; the difference in length was greater in the lower extremities and amounted to one

* Read before the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 8, 1935.

and a quarter inches. A paradoxical lateral curvature, degree one, prevailed in the anomalous lower spinal segments; there was no asymmetry of the remainder of the vertebrae. Normal school grade had been achieved.

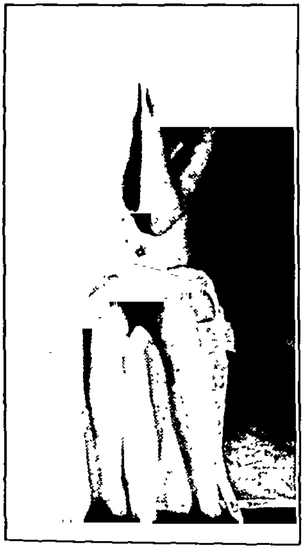


FIG. 1

Case 5. Case of notable total somatic asymmetry, showing difference in size of upper extremities at age of ten.

CASE 2. A boy, aged ten, was seen recently with asymmetry which had not been positively noted before the age of five, but which had definitely increased since that age. There were no skin lesions, and the child was of normal intelligence. The presence of skull asymmetry was questionable, but the rest of the body was smaller on the left side than on the right. The upper extremities differed in length by one and one-eighth inches and the lower extremities by five-eighths of an inch. The asymmetry included both pelvic and shoulder girdles and the ribs, but there was no perceivable scoliosis in the sitting position. Either of the lower extremities would be within normal measurements for age, although the left upper extremity seemed retarded, and it would not be unreasonable to classify this case as a hemiatrophy.

CASE 3. A colored boy, aged ten, was observed with what seemed to be a congenital lymphangioma of the left leg. However, the left arm, while otherwise normal, was half an inch longer than the right and there seemed to be a little facial asymmetry. The left lower extremity was two and one-quarter inches longer than the right. This increase in length was more apparent in the lower than in the upper half of the limb, and indicated some degree of localized gigantism. When the short leg was blocked up, the boy's height was above normal maximum for age, and, because of the localized gigantism, the case could be classified only as hypertrophy. No further observations were obtained.

CASE 4. A mulatto girl, aged eleven, recently came under the author's observation. There was very apparent total asymmetry of the skull, trunk, and extremities. A slight scoliosis in the sitting position was present, which was eliminated by blocking to level the iliac crests. The measured difference in the upper extremities was one and one-half inches and that in the lower extremities was two and one-half inches, the greater length being on the right side. The patient's weight was about the median figure for her age; her height, with the short leg blocked up, was slightly under the high normal limit, but the subtraction of the amount of blocking gave a figure above the low normal. She appeared to be of average intelligence and had attained a normal school grade. While easily classifiable as hypertrophy, this case illustrates the possibility of dogmatic error. Roentgenographic studies are to be made to ascertain the relative progress toward epiphyseal closure, and appropriate arrest of the long leg has been advised.

FIG. 2

Case 5. Amount of blocking necessary to level the pelvis, and indication of inequality in both segments of limb.

CASE 5. A slender girl of Italian parentage was first observed at the age of eight and her case was diagnosed as a right hemiatrophy. She seemed to be of normal intelligence. The asymmetry was quite obviously total, and the right side of the face was contracted as in a severe torticollis. Except for the asymmetry, the general roentgenographic examination showed no abnormalities. A postural scoliosis was completely corrected by levelling the pelvis. The difference in length of the upper extremities was two and one-half inches and that of the lower extremities was two inches. Three years later these differences had increased appreciably,—three and one-half inches in the case of the upper extremities and three inches in the case of the lower extremities. The musculature was generally proportionate to the skeletal structures. The patient's height, with the short side blocked up, was fifty-three and one-fourth inches and her weight was sixty-four pounds. When the amount of blocking is subtracted from her height, a figure just above the low normal for her age is obtained, while the higher figure falls a little below the median. Her weight of sixty-four pounds is also well above the low normal, but below the median. From these figures alone, the inclination would be to classify her with the cases of hemiatrophy rather than with those of hypertrophy; on the other hand, it is the author's belief that tables of height for age in children of the shorter Italian people might well give reason for the opposite classification. In any event, multiple epiphyseal arrests, rather than lengthening, have been advised, since the difference in the extremities is incompatible with normal body function.

This case has seemed to the writer to be of especial interest, not only from the angle of indicated therapy, but also because the asymmetry is many times greater than that seen in any case of hemiatrophy reported in the literature, and it also exceeds quite definitely in degree any reported case of total unilateral hemihypertrophy not associated with local gigantism.

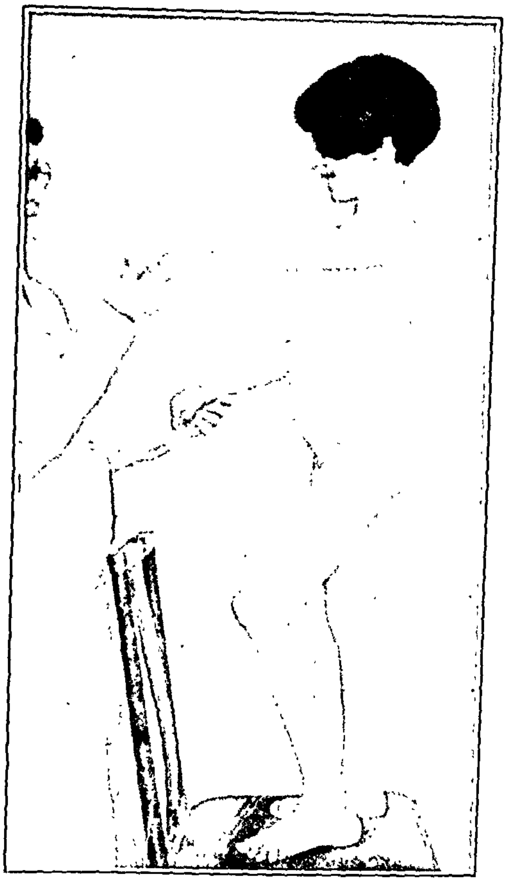


FIG. 3

Case 6. Case of mild general asymmetry plus extreme local gigantism of the long bones of the left lower extremity. In addition to hypertrophy without pathological alteration other than valgus deviation of the long bones, there presented an extreme chondro-osseous hyperplasia of the patella, shown here at an early stage.

CASE 6. A female whose clinic records were available for almost her entire life. At the age of eighteen months, subacute rickets, with bilateral knee valgus, considerably greater in degree on the left side, was noted. No comment was made as to asymmetry, but a very poor photograph suggested asymmetry in the lower extremities at least. A year or so later, in another clinic, a bilateral osteotomy for knee valgus was done, but no other data were included in the record. The next observation, made when the patient was five years of age, included recognition of the asymmetry. The lower extremities only were measured; the left was longer by two inches than the right and there was some knee valgus and enlargement with distortion of the skeletal outlines at this knee. At the age of six, the knee valgus was degree two and the lengthening two and one-half inches. At the age of seven, the knee valgus was degree three

FIG. 4

Case 6. Condition three years after that shown in Fig. 3, with indication of still abnormally large patella following removal of three-fourths of its original structure. Overgrowth of the greater trochanter is suggested in the hip contours. (See Fig. 6.)

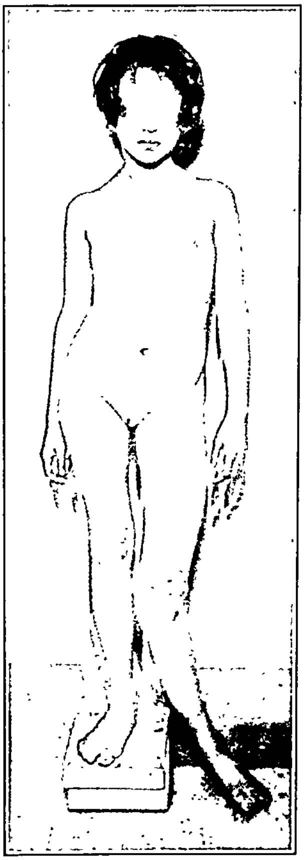


FIG. 5

Case 6. Three years later than Fig. 3, after partial excision of the patella and massive wedge osteotomy of the lower end of the femur. Recurrent valgus (now in the tibia) is seen; also is shown more definitely the asymmetry in the upper extremities, including the shoulder girdle. Blocking (four inches) just levels the pelvis with the knee fully extended instead of slightly flexed as at the moment when the photograph was taken.

and the difference in length had increased to three and one-half inches. At the age of eight, the knee valgus was degree four and the lengthening four and one-half inches. Facial asymmetry had become very definite and there was a difference in length between the upper extremities of one inch. Pelvic asymmetry was apparent both in clinical and roentgenographic examinations: the left greater trochanter above its epiphyseal line was seen to be half again as large as that on the opposite side; the patella seemed to be the site of a chondro-osseous hypertrophy; and a valgus bend appeared in the upper tibial shaft. This deformity was attributed to static strain from the severe knee valgus in spite of apparatus.

Six months later, the lengthening of the left leg had reached five inches. At this time, a wedge resection in the lower femoral region, including the lower femoral epiphysis, was undertaken (Phemister's work had not then been published), but at operation the capsular reflexions were found to be so high that disorganization of the joint was feared from such a low resection. A very large wedge was removed in the metaphyseal region. This procedure offset the valgus deviation both in the femur and in the tibia and shortened the leg by one and one-half inches, as checked by postoperative measurements. Convalescence was uncomplicated and the patient returned to active life in normal time.

Six months later, a further increase in length of one-fourth of an inch was noted. There was also a slight increase of valgus in the tibia. The patellar mass had become so large that malignant degeneration from irritation was feared and this mass was excised. Although the excision included a considerable portion of the normal bone substance, the patella was thicker and larger than normal. The removed specimen was about three

times the size of a normal knee cap. The pathological diagnosis was benign osteochondroma.

By the time the patient had reached the age of ten, the lengthening of the leg had again increased to four and one-half inches, and a valgus deviation of 30 degrees, mostly below the knee, prevailed. No further enlargement had occurred in the patella, but the greater trochanter was now double the size of that on the opposite side, although otherwise normal in roentgenographic appearance. About this time there was performed a very extensive step-cut resection in the upper half of the tibia and the fibula. After this operation, the difference in length was reduced from four and one-half inches to two inches, and the valgus deformity was entirely eliminated by swiveling the fragments at the time of the resection according to the writer's method.

This status prevailed for about six months, but one year later there was again a difference in length of three inches (about the same rate of increase) and an apparent knee valgus, degree two. Roentgenographic examination indicated very little skeletal valgus deviation, but a mass about the size of a patella was revealed at the inner side of the knee in the usual position of the shadow seen in Pellegrini-Stieda disease. At that time, the tip of the greater trochanter had reached the side of the pelvis, and abduction was completely blocked. Shortly afterward, the patient left the city and the author has been unable to obtain further information about her.

This case, the most bizarre of the lot, is of interest in connection with the operative treatment carried out and also because the patient had attained a relative lengthening of seven inches in the lower extremity at the age of eleven, when observations were terminated. Such an increase is unique in a case of unquestionable total unilateral hemihypertrophy, even when combined with local gigantism. Furthermore, certain sites of

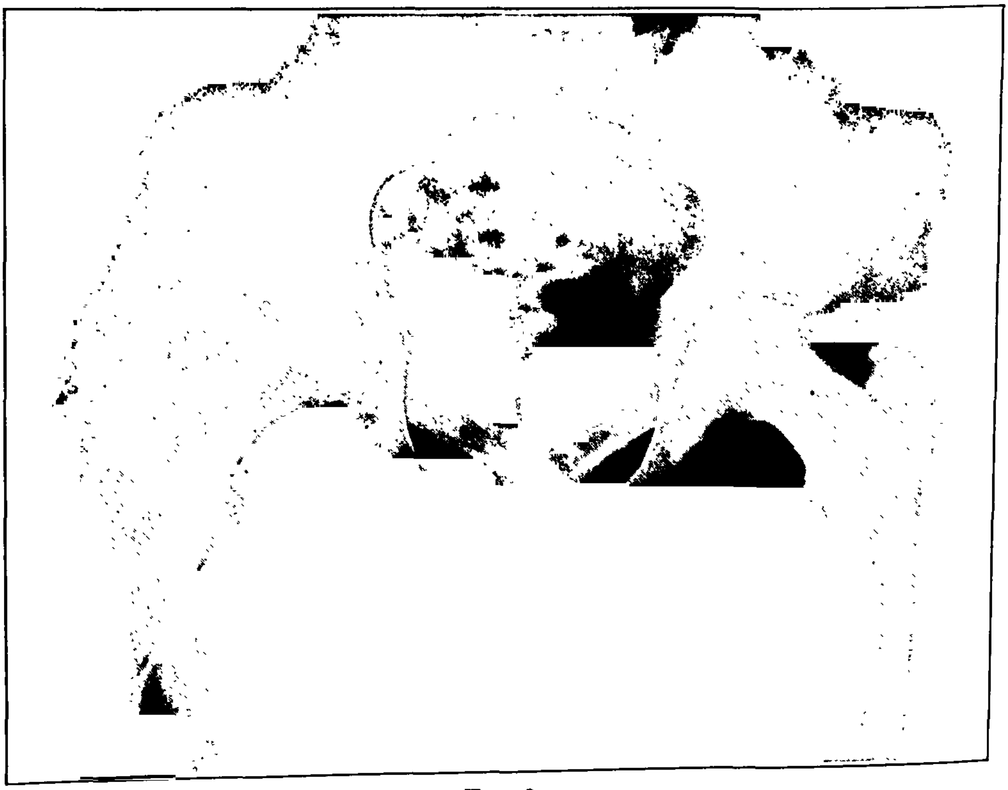


FIG. 6

Case 6. Roentgenogram showing pelvic asymmetry and localized gigantism of the greater trochanter.

gigantism noted in this case have not been previously reported in the literature.

DISCUSSION

In this series of six cases, there are some findings which, considered against the background of previous reports, suggest rather unusual if not unique characteristics. The author cannot say that the study has seemed to throw any real light on the question of etiology, and in this report no preventive treatment has been suggested.

In discussing the theories of causation or etiology that had been advanced, Gesell stated that all were of a purely speculative nature and could be given very little logical support. His own theory, also speculative in a way, has nevertheless very good arguments in support of it and seems plausible. He argues biologically that the organism is essentially one of a "two-ness" character, which occasionally manifests itself in various anomalies up to complete twins, and that hemihypertrophy is an instance of partial twinning, or a union into one organism of two different halves. He terms it an epigenetic deviation, rather than a germinal deformity.

Against this theory, is the existence of rare cases of crossed hemihypertrophy, more frequent instances of partial hypertrophy or partial gigantism (one member or one portion of a member), and rare cases of total unilateral hemihypertrophy with associated extreme partial gigantism, of which this present report includes an instance. However, the literature does also include two autopsy reports in which the visceral organs were described as being asymmetrical, in proportion to the somatic portion of the body. Also against the twinning theory is the almost uniform absence of anything but a postural scoliosis and no observations of asymmetrical development of the bodies of the vertebrae, although the ribs seem to be uniformly affected. A theoretically intriguing explanation of asymmetry might lie in a supposition of unbalanced action of the sympathetic chain which might give rise to an inequality in blood flow or distribution with the resulting overgrowth that is commonly seen in the local gigantism or the spurious hemihypertrophy which accompanies diffuse angiomata. No reported observation has been found of differences in surface temperature on the two sides, nor have such differences been apparent to the examiner in the writer's cases.

Gesell does not discuss congenital total unilateral hemiatrophy and, in this connection, it may be fair to say that there is considerable doubt in the author's mind as to whether these two types are really separable as opposite developmental entities. At this stage, it should be emphasized that the condition under discussion consists of a difference between the two sides of the body of a purely quantitative character, as a rule involving uniformly all the included tissues, and it may be more proper—certainly for the vast majority of reported cases—to regard the condition simply as a quantitative asymmetry, rather than specifically as an

atrophy or hypertrophy. In children and adults, all of the cases reported as atrophy, and the great majority of those described as hypertrophy, represent dimensional differences which are well within the maximum range for age of normal individuals. The term used, therefore, may well be the result of the reaction of the observer. For instance, in many cases the difference in size has been considered by the parents from one point of view, and by the reporter from the opposite. In an individual on the low side of normal size, it is easy to denote an asymmetry as an atrophy, and, conversely, as a hypertrophy.

By far the larger number of reported cases of hemihypertrophy have been in infants and it is curious to note that at this age the differences in girth are relatively greater than those in length. The author's own cases consist of older children, with either a perfectly proportional asymmetry in these two particulars, or else a somewhat greater difference in length than in girth. In infants, the reported differences in length have varied between a quarter of an inch and an inch; in children and adults, from half an inch to two inches. This discrepancy in length had apparently occurred before adolescence. About half of the author's series show a difference in length in excess of that in cases previously reported, which continues to increase into adolescence. It has usually seemed to be the case that the asymmetry between the two sides increases in degree in the following order: skull, trunk, lower extremity, and upper extremity. In some instances, the amount of variation has been not only relatively, but actually greater in the upper extremity than in the lower.

Gesell's two patients were mentally deficient to a marked degree. On this fact he placed considerable significance, for, although in the cases reported up to 1927 only 15 per cent. of the patients were found to be mentally deficient, a minority had reached an age of accurate measurability in this respect. However, in all reported cases over five years of age, the percentage of mental defectives is no greater. In the author's series, there were no cases of mental deficiency.

In cases reported as hypertrophy, females were affected slightly more frequently than males and the right side more often than the left. Congenital skin lesions were present in 40 per cent. of the cases of hemihypertrophy; such lesions occurred much more frequently, however, in the few cases listed as hemiatrophy. There was a greater frequency of other congenital anomalies in these cases than is usual.

No consideration has heretofore been given to control or relief of this deformity, probably because the asymmetry has very rarely developed to any handicapping degree. A difference of two inches in the length of the lower extremities has been reported a few times, but usually a moderate shoe lift has easily compensated for the resulting postural complication. In four of the six cases in the author's series, the situation was more serious. Inasmuch as the maximum difference seems likely to prevail in early adolescence, the writer now believes that procedures to bring about epiphyseal arrest may have rather definite indications in cases of major asymmetry.

SUMMARY

The congenital anomaly of total unilateral hemihypertrophy and hemiatrophy is either becoming more frequent or more commonly recognized. Its causation remains without satisfactory explanation. The discrepancy in growth may interfere with efficient body function sufficiently at times to indicate measures of control, which the writer believes should consist of epiphyseal arrests at appropriate ages.

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Note.—Some forty-three additional references have been examined and, although titled as hemihypertrophy or hemiatrophy, thrown out as not fulfilling the requirements of total unilateral asymmetry. Thirty-one reports appearing prior to Gesell's first article have also been investigated by the writer. This search of the literature for suggestive titles was carried out at the writer's expense by the Literary Research Department of the American College of Surgeons and the results should remain available for any subsequent study.

EPIDERMOID CYST IN BONE OF SKULL

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From the Department of Surgery, University of Toronto

That an epidermoid cyst should appear within bone is remarkable. That as many as seven of these cysts should be described in the surgical literature is even more remarkable. The peculiar growth of a cyst (purely ectodermal in origin) within bone (a purely mesoblastic structure) merits some comment. Yet such are the facts and the illustrative cases come from widely separated parts of the world. The subject of this communication is the description of such a cyst occurring in the parietal bone of the skull.

Such cysts in bone have been reported, as far as can be determined, only seven times. The first case was reported in Germany, in 1923, by Sonntag who described a cyst occurring in the terminal phalanx of a finger which was treated by amputation. He concluded that the causal relationship between injury and cyst formation must be accepted. Friedländer, also in Germany, described in detail two cases, both of which occurred in the terminal phalanx of the finger. He reviewed the theories of causation of epidermoid cysts in general, and, like Sonntag, with characteristic German thoroughness, treated his cases by amputation.

Christopher, in the United States, in 1925, described a typical case, concluded that it was traumatic in origin and removed readily by operation, and drew attention to pressure atrophy of the surrounding bone.

Harris, of Toronto, in 1930, outlined a characteristic history and suggested the traumatic theory of causation.

In 1932, Curtis and Owen added a case to the literature.

Finally, in a previous article[2], the author described a typical case, suggested that traumatic implantation is the most readily acceptable theory of causation, and outlined a typical history and examination on which diagnosis could be made.

These cases are all in the terminal phalanx of the fingers, which is significant when considering cause.

The only case described as occurring in the skull, so far as the author can determine, is that reported in 1921 by de Castro, who described the removal of a cyst from the scalp, leaving in the skull a round "trephine-like hole", the size of a "four-anna piece". His description suggests that the cyst was infected at the time of operation.

Hartley, however, in 1896, described a similar cyst, implanted by the trauma of a compound fracture of the skull and finally developing not only inside the skull but actually under the dura. There seems to be no reason why these cysts should not develop anywhere in the body if tissue is transplanted.

CASE REPORT

Mr. H., twenty-five years of age, was admitted to the Toronto General Hospital for an entirely different condition. On routine physical examination, a "wen", one centimeter in diameter, was found lying over the right parietal bone. This "wen" differed from other wens, in that a sharp bony margin could be felt all around it. The roentgenogram (Fig. 1) showed a round clean-cut hole through both tables of the skull. The hole through the outer table was larger than that through the inner table. A history of injury to the forehead and scalp, which had occurred years previously and had required stitches, was confirmed by a scar on the forehead. A diagnosis of epidermoid cyst was made.

Under local anaesthesia, the cyst was neatly removed by Dr. Stuart Thompson. It lay under the gala aponeurotica, and under periosteum. After these structures around the bony rim of its cuplike bed were divided, the cyst could be peeled readily from the surrounding tissue, leaving in the skull a clean round hole, resembling a burr hole except that it was lined by a smooth layer of bone so that cancellous bone of the diploe was not seen. The hole through the inner table exposed normal dura. After the cyst had been rolled out, the soft-tissue layers were closed over the bone defect (Fig. 2), and the wound healed by primary union.

FIG. 1

Roentgenogram showing hole through both tables of the skull.

The presence of the thin shell of bone, hiding diploe, suggests, as did the author's previous case in which the cyst was located in the finger, that bone production is stimulated as well as bone destruction, so that, in response to some unknown stimulus, a shell of new bone is laid down outside as fast as the bone is eroded inside. Thus, the bone production exactly kept pace with the pressure erosion which produced the "burr hole" or nest for the cyst.

This peculiar action of epidermoid cysts in stimulating the production of new bone as well as in producing atrophy, probably due to pressure, has been remarked before. In all cases of epidermoid cysts occurring in the bones of fingers the same phenomenon is observed. Christopher refers in his title particularly to the pressure atrophy of bone, while Harris observes that the phalanx gives the appearance of having been "expanded" by the cyst. However, since bone does not expand, it must be that "new bone is laid down outside as it is eroded inside" [2].

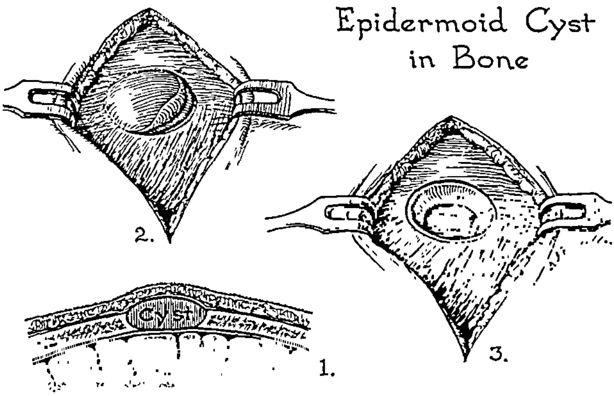

FIG. 2

Semidiagrammatic sketches showing cyst lying in shell of bone under periosteum, but outside dura.

To elaborate various theories of causation of epidermoid cysts is simply to set up straw men for the sake of knocking them down. The following observations, especially when taken together, support the simple and satisfying explanations of traumatic implantation of cells to varying depths in or below the skin where they live and grow and produce an epidermoid cyst.

1. In the first place, epidermoid cysts occur most commonly in the soft tissues of the palmar aspect of the hands of working men. In this respect, the author's observations confirm those of both Unna and Ewing, who point out that these areas are exposed to many small injuries and that cysts in such a location are common in working men. Furthermore, all cases deep enough to be in bone occur in the terminal phalanx.

2. Three cases in the skull are mentioned, two of which are definitely associated with injury. Certainly the head is more prone to cuts or blows than the covered parts of the body.

3. Epidermoid cysts can be produced experimentally [9] by the implantation of epidermoid tissue beneath the surface.

4. Plastic surgeons resort to the device of burying strips or sheets of skin to gain epithelium-lined surfaces. These pieces promptly grow from all edges, complete the circle, and produce a cyst lined by stratified squamous epithelium.

Furthermore, there is some reason to suggest that epidermoid cysts and wens are identical. It has been stated that epidermoid cysts are the result of implantation and that wens are the result of blockage of the ducts of the oil glands. The latter statement is open to question.

The parallel between hand and head is too good to let pass. In the hand, the part of the body most exposed to injury, traumatic implantation produces epidermoid cysts in soft tissue and occasionally even in bone. In the head, also prone to occasional trauma, whether due to a blow, a comb, or a scratch, cysts often occur in the soft tissue and occasionally even in bone. The bone cysts are admittedly due to traumatic implantation. It is suggested, therefore, that the soft-tissue cysts or wens are also traumatic in origin. But, it will be objected, the texts state that wens are attached to the skin and that epidermoid cysts are not. The texts are wrong. There is no reason why an epidermoid cyst of traumatic origin should not be implanted at any depth—in skin, beneath skin, even in bone—and, if close to skin, it will be attached.

At this point, the microscopist will tell us that an epidermoid cyst is lined with stratified squamous epithelium, while a wen, being a retention cyst in an oil gland, is lined with tall secreting epithelium. He then goes naïvely on to add that after some time the taller secreting epithelium is damaged by pressure and replaced by *stratified squamous epithelium,* so that the two are indistinguishable. Further comment is unnecessary.

In conclusion, then, the author not only favors the traumatic-implantation theory of causation, but also suggests that many so called wens or sebaceous cysts are in reality traumatic epidermoid cysts.

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CONGENITAL ASTRAGALOCALCANEAL FUSION

BY SIDNEY S. GAYNOR, M.D., NEW YORK, N. Y.

Assistant Adjunct Orthopaedic Surgeon, Hospital for Joint Diseases and Lenox Hill Hospital, New York City

Congenital coalescence of the tarsal bones is a relatively rare anomaly. Recently, however, such instances have been reported with increasing frequency, due probably to the more universal employment of the roentgen ray in the diagnosis of foot disorders. Fusion between the navicular and the astragalus seems to be present in the majority of cases [1, 3, 5, 6, 9, 13]. Coalition of the astragalus and os calcis, however, has been encountered so infrequently that the presentation of another case may be condoned.

P. H., a butcher, thirty-nine years old, was referred to the author for the treatment of traumatically induced low-back pain of four months' duration. The patient had previously enjoyed excellent health, although he had a pronounced valgus of the left heel, of which he had been aware all his life. There was no history of injury or illness affecting his left foot. He did not know of any of his forebears with a similar condition. He had never suffered any pain or disability because of his foot, although it had been the reason for his exemption from military service during the World War.

On examination, the body weight appeared equally distributed between both feet. The heels were maintained in valgus, greatly pronounced on the left. Both forefeet were moderately abducted with the longitudinal arches well preserved. The feet felt normally warm to touch and the arterial pulses were easily palpable in their usual location. There were no callosities on the plantar surface of either foot. The skin of the left foot was normally mobile and no scars were discernible. The web between the second and third toes on each foot was extended distally to the proximal interphalangeal joint.

The musculature of both feet appeared normal in power. Motion at the right ankle and tarsal joints was free and unrestricted. There was absolutely no motion in the left astragalocalcaneal joint, nor could the astragalus be rocked laterally in the ankle mortise. The range of motion at the left ankle exceeded that of the opposite side by about 20 degrees. There was also a wider excursion of abduction and adduction of the left forefoot than of the right.

Roentgenograms were taken of both feet. The right foot appeared normal in all respects. There was complete bony fusion between the left astragalus and the os calcis, with continuous bony trabeculation joining both bones. The posterior external talar tubercle was absent on the left side.

Congenital astragalocalcaneal synostosis was first reported by Zuckerkandl in 1877. Since then, additional isolated reports have been received from Leboucq, Morestin, Pfitzner, and Korvin. In most cases, no consideration of the etiology of this condition has been undertaken. Leboucq observed an astragalocalcaneal fusion in a foetus of sixty-five millimeters, and was of the opinion that this condition was due to failure of proper differentiation of the pre-articular mesenchymal anlage between these bones. Johansson reported a case of multiple congenital malformations associated with fusion of the ankle and proximal tarsal bones. From the mother, he elicited a history of the presence of an unusually small quantity

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FIG. 1
Lateral roentgenogram of left foot. Complete bony fusion between the astragalus and the calcaneum, with absence of the posterior external process of the astragalus.

FIG. 2
Lateral roentgenogram of the right foot revealing normal joint space between the astragalus and the calcaneum and a well-defined posterior external talar process.

of amniotic fluid during pregnancy. Therefore, he believed that this case greatly strengthened Murk Jansen's theory of deranged amniotic physiology as the causative factor in the production of congenital deformities.

The possibility that astragalocalcaneal fusion is developmental in origin was suggested to the author by a case presented by Bentzon, who found complete absence of motion at the subastragalar joint associated with unusual prominence of the posterior-superior process of the os calcis and absence of the posterior external talar tubercle. This, he believed, was due to coalescence between the os trigonum and the calcaneum,—a variation of the usual occurrence of the os trigonum as a separate ossicle or of its fusion with the posterior external talar tubercle.* The rarity of this anomaly of the os trigonum is brought out by the fact that Burman and Lapidus did not encounter a similar situation in 493 cases personally observed or in a review of the literature.

It has occurred to the author that, since fusion of the os trigonum to the astragalus is a common finding, and since fusion between the os trigonum and the calcaneum has been observed[2], it is not entirely unreasonable to expect the rare condition in which fusion occurs between the os trigonum and both the talus and calcaneum. Therefore, consideration should be given to the possibility that the aberrant development of the os trigonum is the cause of astragalocalcaneal fusion.

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* Burman and Lapidus state: "The normal posterior external tubercle of the astragalus is small. In our study, and in accordance with the concept of many authors (Gray, Dwight, Holland, and others), we have considered any enlargement or elongation of the posterior external tubercle due to fusion of the os trigonum with the small posterior external tubercle."

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FRACTURE OF THE ACETABULUM WITH CENTRAL DISLOCATION OF THE HEAD OF THE FEMUR

A Method of Treatment

BY FREDERICK A. JOSTES, M.D., F.A.C.S., ST. LOUIS, MISSOURI

From the Department of Surgery, Washington University Medical School and St. Louis County Hospital

The treatment of this type of fracture has long been debated, and justly so, because of its intangibility. No traction device nor mechanical means has, to the author's knowledge, been offered which enables one to replace the acetabular fragments which have been displaced inward by a force from without in the direction of the line of the head of the femur. The method described in the following case was devised to replace the fragments in a fracture of the acetabulum with central dislocation of the head of the femur.

F. P., aged thirty-three, a physician, was injured on May 3, 1933, when the car in which he was riding was struck by another. The contact came on the right side. As a result, the patient sustained a fracture of the pelvis and was in shock. He also sustained fractures of the fifth, sixth, seventh, and eighth ribs on the right side in the postaxillary line. As shown in Figure 1-A, the head of the femur went through the acetabulum, displacing fragments of the acetabulum ahead of it. These fragments, three in number, were quite angular. The superior margin of the acetabular ring rested against the greater trochanter. The leg was in very mild abduction. There was bleeding from the genito-urinary tract, as well as from the mouth. Traction was applied to the right leg and the ribs were fixed with adhesive strapping. After fourteen days, the patient was moved to the St. Louis County Hospital, some 200 miles from the scene of the accident, where the following treatment was carried out.

Method of Treatment

The right leg was first put in Buck's extension. A Thomas splint was used, but no countertraction was exerted against the ischium. Countertraction was obtained by lowering the head of the bed. Lateral traction on the trochanter can best be obtained by use of skeletal traction applied through the trochanter. Since the patient was a physician, a more conservative method was used at his request. A wide sling was made of adhesive and tongue blades, after the fashion of a coaptation splint, and was placed so as to bring about lateral traction on the upper third of the femur. After several days, the head of the femur was brought out to a fairly normal position; however, the fragments of the acetabulum remained displaced as before. Also the fossa for the head of the femur remained so large and so deep that each time that lateral traction was released the head would again dislocate centrally, almost to the position following the accident.

It was then decided that something must be done to restore these acetabular fragments to what approximated their normal position, in order that they might help to maintain the corrected position of the head of the femur. From all indications, only an operative procedure could bring about a reduction. This was considered hazardous. The patient did not regard such a procedure very favorably, nor was he a very good operative risk. It was then decided that, without an anaesthetic, an attempt should be made to replace these fragments by manual manipulation through the rectum. The

FIG. 1-A

Roentgenogram of pelvis, taken May 18, 1933, showing fracture of the acetabulum with three fragments protruding into the pelvic canal: one (*1*) from the lower anterior (pubic) ramus; one (*2*) from the lower posterior (ischial) ramus; and one (*3*) from the superior (iliac) part of the acetabulum, including that portion of the ilium which approximates the sacro-iliac joint. There is also a fracture through the wing of the ilium (*4*) from about the midpoint of the crest of the ilium between the anterior-superior and posterior-superior spines downward to the superior margin of the acetabulum. Also evident are fractures of both pubic rami (*5*) and (*6*), in close proximity to the synchondrosis.

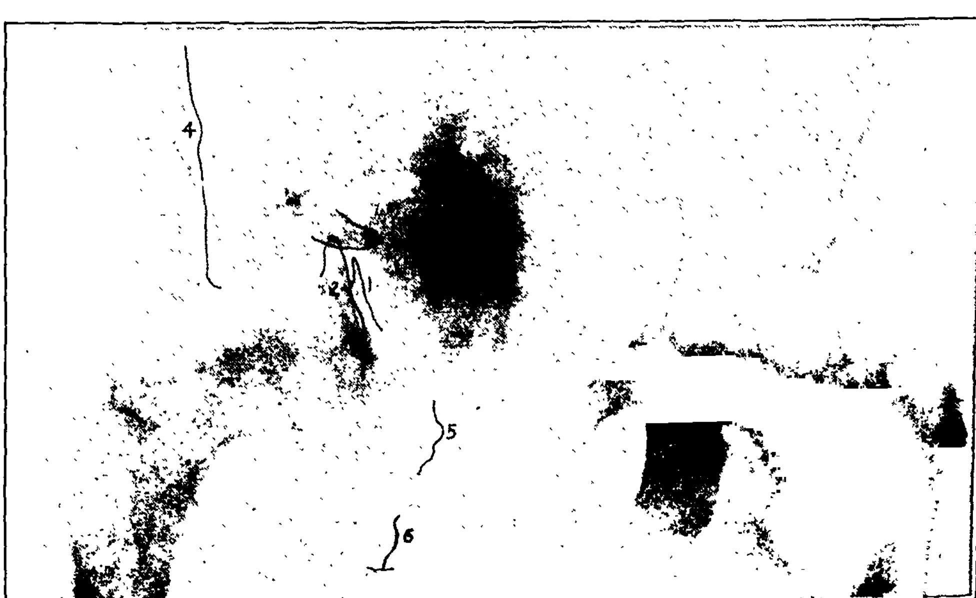

FIG. 1-B

Roentgenogram, taken May 22, 1933, showing position of the head of the femur after application of traction and manipulation.

FIG. 2-A

Fifteen months after accident, showing degree of flexion obtained by the patient.

FIG. 2-B

Fifteen months after accident, showing degree of abduction.

End Result

Three years have elapsed since the patient sustained his injury. At present, he is engaged in the active practice of medicine, drives his car, participates in sports, and leads a normal life in every way. He has a normal range of motion in both hips and suffers no pain. (See Figures 2-A and 2-B.)

While this method seems hazardous, the procedure can be carried out with little danger to the patient when reasonable care is exercised. The result obtained in this case seems worth the effort.

AN EVALUATION OF PRESENT-DAY METHODS OF DEALING WITH CONGENITAL DISLOCATION OF THE HIP *

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The treatment of congenital dislocation of the hip has undergone such a marked change in recent years that there is some confusion in the minds of orthopaedic surgeons. When the methods of Paci and Lorenz became known, bloodless reduction was universally accepted and practised as the rational treatment of this condition. Numerous methods of reduction were devised,—some gentle, many violent. Many tables of statistics were published which led us to believe that from 50 to 70 per cent. of the cases of congenital dislocation could be cured by bloodless reduction. Except in a few isolated instances, nothing was done at that time for those cases which could not be thus cured.

Then the advent and perfection of asepsis wrought a profound change in all fields of surgical procedure. Dissatisfaction with the results of bloodless reduction began to arise. In America, Sherman and Galloway began the practice of open reduction and advocated it as the method of choice in all cases. This bomb, thrown into the camp of the bloodless surgeons, produced some consternation and other emotional disturbances, but caused them to inspect their position more carefully to see if it was tenable. They began to recognize the dangers of forcible manipulation and to insist on the use of only the gentle methods of reduction. But this, certainly, did not increase the number of cases cured by bloodless reposition of the hip.

Furthermore, it has become quite evident that the older meaning of "successful reduction", whether by closed or open methods, is not altogether correct. In many cases, dislocations which had been recorded in our private practice or in our public clinics as having been satisfactorily reduced were found in after years to have recurred. The paper recently published by Heyman calls this forcibly to our attention. For this reason all statistics published more than ten years ago and even more recently must be discarded as giving inaccurate percentages of successful reduction unless they were based upon precise observations of the cases for many years after the reduction.

In recent years, Putti, with his associates and followers, has proved the tremendous advantage of treating congenital dislocation in the early weeks and months after birth. His observation of patients treated by abduction in early infancy shows that at the end of five years or more over 80 per cent. of them have been cured. However, this work, valuable as it is in showing the need for very early diagnosis and treatment, leaves unsolved the treatment of the 20 per cent. or less not so cured and the treat-

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ment of the vast number of patients with congenital dislocation who have reached the walking age before the condition has been discovered. It seems merely to place the young infant in a class by himself, and to emphasize the necessity of the education of the medical profession in order that the obstetricians and pediatricians may make an early diagnosis of this congenital defect.

Another development of the past fifteen years has been the concentrated attack upon the old or irreducible dislocation, in order to ameliorate or relieve the pain and disability attendant upon it. Through the many operations done upon the luxated hip, whether for the purpose of reducing the dislocation or improving a condition not entirely curable, our knowledge of the pathology of congenital dislocation and of the difficulties of complete reduction has been enlarged.

Therefore, we are now more able to discern the important underlying principles of congenital dislocation of the hip and to outline a rational course of treatment by bloodless and open reductions and by palliative operations.

BLOODLESS REDUCTION

Many cases of congenital dislocation of the hip are susceptible of cure by skilful manipulation. Time and experience have proved this beyond the shadow of a doubt. Many cases cannot be so cured. Our first great problem, therefore, is to distinguish between these two major groups. Shall we operate upon all; shall we operate upon none? If the premises enumerated be accepted, the former course must appear as reprehensible as the latter.

Congenital dislocation of the hip is due to the failure of normal development of the hip joint during embryonal and foetal life, as described by Stewart, Putti, Dega, Böhm, and others. The departure from the normal may be very slight or it may be extreme, with many degrees of variation between these limits. We are thus forewarned that no one method of treatment, whether it be a method of bloodless reduction or one of open operation, is applicable to all cases. Furthermore, in hips that are not far removed from the normal, we may reasonably expect to secure a return to normal structure and function by adequate treatment given at the proper time.

In early life, the structures of the hip are most plastic and are molded very easily. As time passes, there is an increasing fixity of the tissues and progressing deformity because of the effort of the elements of the hip joint to adjust themselves to their abnormal relations and functions,—to make the best of a bad situation, as it were. We may, therefore, understand the successful results obtained by Putti and others in the treatment of infants; and, furthermore, we may appreciate that the remainder of this paper deals only with the treatment of individuals who have reached or passed the age at which they begin to walk.

No time limit can be set for successful bloodless reduction. It

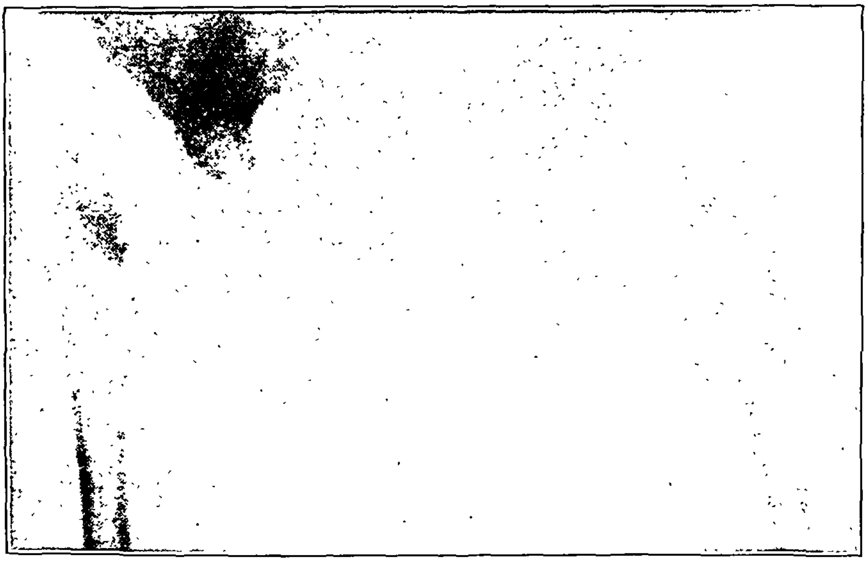

FIG. 1-A
Case 1. R. D. R. Bilateral dislocation.

FIG. 1-B
Case 1. R. D. R. Ten years after bloodless reduction: normal motion; normal function; almost normal anatomical development.

depends on the severity of the deformity at birth and its progress afterward. Experience has shown that bloodless reduction cannot often be accomplished after the fourth year.

The surgeon's first decision must be whether to attempt bloodless

reduction or to resort at once to open operation. Contra-indications to the former are rigidity of the hip—sometimes accompanied by rigidity of other joints and by congenital club-foot—high bilateral dislocation, marked deficiency of the acetabulum and deformity of the head and neck of the femur, and an age beyond four years. Bloodless reduction should be attempted in all favorable cases and even in border-line cases.

The manipulation should be gentle and skilful. All the weight of present opinion is opposed to forcible methods of reduction. If the manipulation is unsuccessful, nothing has been lost and no damage has been done. No bones have been broken; no muscles and ligaments have been ruptured; and no cartilages have been damaged by active violence or succeeding excessive pressure.

If the dislocation has been reduced, has the manipulation been successful? By the term "successful reduction" the author means that we may expect the hip to become anatomically and functionally perfect, or so nearly so that it will be the cause of no pain and disability in later life. Time is the only absolute criterion, but in many cases we cannot wait for the passing years to answer our question. The following observations may assist us in determining whether to await the natural outcome or to

Fig. 2

Case 2. W. M. Eight years after bloodless reduction of left hip at age of sixteen months. Four years after reduction, Legg-Perthes disease was noted; healing has now taken place. Normal motion and function are present. Moderate shallowness and obliquity of the acetabulum may be noted, as well as slight deformity of the head which corresponds with the contour of the acetabulum. *Would it not be desirable to correct the obliquity of the socket now in order to secure normal development of the head?*

FIG. 3-A

Case 3. J. M., a sister of patient in Case 2. Eight months after bloodless reduction at age of two years and six months.

FIG. 3-B

Case 3. J. M. Three years after reduction. Function and motion are normal. The acetabulum has been improved, but is still defective. The head shows evidence of Legg-Perthes disease. Should not the shallowness and obliquity of the acetabulum be corrected by operation at the present time?

FIG. 4

Case 4. R. C. Seven years after bloodless reduction at age of three years. Motion and function are normal. The acetabulum is shallow and oblique. There is moderate deformity of the head corresponding with the acetabulum. Should not the defect of the acetabulum be corrected by operation?

proceed at once to open operation. If, during the manipulation, the head slips very easily into the socket without the "snap" that has been so frequently spoken of and again slips out just as easily, this is a fair indication that the socket is inadequate to retain the head or that the head has not entirely entered it. If the roentgenographic examination following reduction shows the head to be opposite the acetabulum but not within it, as determined by comparison with the normal hip, and the acetabular roof to be markedly defective in size and in obliquity, often containing a gutter, the chances are poor that a successful reduction has been accomplished, and an open operation should be done.

FIG. 5-A

Case 5. A. O'B. One year after bloodless reduction at age of two years. There is marked evidence of Legg-Perthes disease.

If the head is in an apparently adequate acetabulum, the author maintains the reduction with plaster for four months. At the end of this period, the cast is removed and the child is allowed to kick about in his crib for several weeks. If redislocation does not occur,

the child is allowed to walk. If, at any time after the initial four months in plaster, dislocation occurs, an open operation is done. This may seem to be a very arbitrary procedure and test, but the author's experience leads him to believe that it is a sound one for most cases. There may be a few exceptions. This method has the following advantages: first, we determine in four months, and not years later, whether or not the head will remain in the socket—in other words, whether or not the structures of the hip are too abnormal to permit anatomical and functional cure; second, we prevent the atrophy of bone and muscle which is due to prolonged fixation in plaster; and, third, we reduce the medical cost of the case. If some of the readers are fearful of allowing so early weight-bearing on a hip replaced without violence and, therefore, under no great intra-articular pressure, and choose to give the child exercises in water or in any other non-weight-bearing fashion, the author will not quarrel with them. However, the facts should be remembered that the child has been bearing weight on the head of the femur, even though it has not been in the socket, and that nature develops best those structures of the body which are performing their normal functions. Bearing weight is part of the function of the hip. If the head of the femur is so soft that it would be damaged by bearing weight at this period, the hip probably belongs in the category of those which cannot be successfully cured by bloodless reduction.

FIG. 5-B

Case 5. A. O'B. Two years after reduction.

FIG. 5-C

Case 5. A. O'B. Two and one-half years after reduction. Motion and function are normal. The head is slightly flattened and the neck is broad and short. There is moderate obliquity of the socket of the acetabulum.

Doubtless, the

FIG. 6-A

Case 6. H. F. Dislocation of the left hip and subluxation of the right hip.

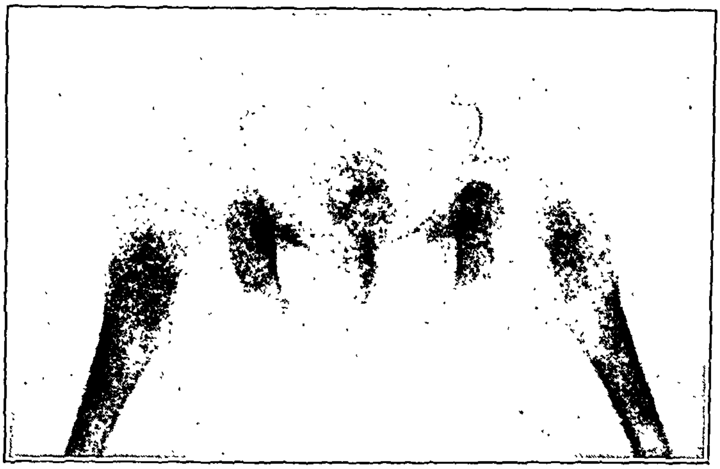

FIG. 6-B

Case 6. H. F. Seven months after bloodless reduction at age of two and one-half years.

FIG. 6-C

thought has entere the reader's mind tha there must be bu few hips that ca qualify for successfu bloodless reductio under these condi tions and tests. Th author can assure hin that there are some although what th percentage is he doe not know. It i smaller than we thought in former years. Why, therefore, not follow the advice of some and operate upon all hips, and thus avoid delay and indecision? Doubtless such a course would be easier for the surgeon. He would no longer need to cultivate his patience and his powers of observation and judgment. He would merely lay out a single undeviating course and pursue it. The mariner at sea adjusts his course to the winds and the tides and the deviations of the

FIG. 6-C

Case 6. H. F. Two years and three months after reduction. Motion and function are normal. The structure of both hips is defective; this is more evident in the right hip which was never fully luxated. *Should not both defective acetabula be corrected?*

FIG. 7-A
Case 7. D. C. Seven months after bloodless reduction at age of three years and three months.

FIG. 7-B
Case 7. D. C. One year and six months after reduction, showing increasing structural improvement in the acetabulum. Two and one-half years after reduction there was perfect function. Motion was normal and there was no limp.

FIG. 8-A
Case 8. J. B., aged four years.

FIG. 8-B
Case 8. J. B. *Four years after bloodless reduction.* Both acetabula are defective and there are corresponding defects of the heads of the femora. Reconstruction of the right acetabulum was advised.

compass lest he land on the rocks. As in navigation, so in surgery, there is no fixed undeviating course. Let the operative surgeon show us better results than those obtained by our successful closed reductions before we decide to operate upon all congenitally dislocated hips.

OPEN OPERATION

Operative procedures fall naturally into two classes: first, those which offer a reasonable hope and expectation of effecting a cure, so that the hip joint may be restored to something that closely approaches the normal, both in structure and function; and, second, those which are palliative.

If a dislocated head of the femur can be replaced within the acetabulum, if the acetabulum is or can be made of sufficient depth to admit the entire head, and if the acetabular obliquity is or can be made normal, then we may reasonably expect to effect a cure by open operation. On the contrary, any open operation to cure congenital dislocation which does not take cognizance of these three vital conditions may reasonably be expected to fail. A surgeon who merely opens the hip joint, replaces the head in the acetabulum, and then closes the capsule will have as many failures of permanent cure as the surgeon who replaces the head in the socket by bloodless manipulation. Nor will his good results be any better than the good results of the bloodless surgeon. In other words, the cures effected by both occur in those hips which have departed but little from their normal structural develop-

FIG. 9-A
Case 9. J. F., aged seventeen months.

ment. According to Kidner, the replaced head will remain in the socket after fixation in plaster for three months, or after four months in plaster, as more conservatively stated by the author in considering bloodless reduction. If we review the cases of bloodless reduction which we have failed to cure, although we may have thought the reduction satisfactory at the time, we shall find that the head was not entirely within an adequately deep socket or, if it was, that the roof of the socket was too sloping to maintain the reduction. When Kidner reviewed the results of open reposition he found the same factors in the cases that were not cured.

By what methods of operation, therefore, can we correct

FIG. 9-A

FIG. 9-B
Case 9. J. F. One year and four months after bloodless reduction.

FIG. 9-C
Case 9. J. F. Five years after reduction. This roentgenogram shows very marked structural defects. In this case normal structure and function could not be expected from any method of treatment.

FIG. 9-C

Fig. 10-A
Case 10. M. M., aged nineteen months.

Fig. 10-B
Case 10. M. M. Five months after bloodless reduction. *The head is opposite the acetabulum, but not in it.*

Fig. 10-C

these defects in th structural develop ment of the hip Three important con siderations *must* b borne in mind.

1. It must b possible to place th head in the socke without undue ten sion upon the sof *structures of the hi* and consequent ex cessive pressure upon the articular carti lages or *without in jury to these* struc tures during the re placement of the head This is just as impor tant in open as in closed reductions Failure to observe this condition may result in stiffness, in anky-losis even, or in de-generative processes that alter normal structural develop-ment.

If the surgeon has already attempted a bloodless reduction, he will be aware of this possible hindrance *to open reduction.* He may be able to overcome the shorten-ing of the soft struc-tures by gradual trac-tion on the extremity with a turn-buckle

Fig. 10-C
Case 10. M. M. Ten months after reduction.

cast, or with any other appliance which he may have found to be effective. Stretching of the soft tissues should be done slowly in order not to disturb the blood supply to the structures of the hip and in order to avoid sloughing and pain. The traction should be maintained for some time after the head has been drawn down to the level of the socket, so that there may be thorough readjustment to the altered position of the head and, therefore, less tendency to intra-articular pressure after the operation. In accordance with accepted orthopaedic principle, the deformity should be not merely corrected but overcorrected. In mobile hips, this procedure may require a period of a few weeks or a period of four months or more in the more rigid hips.

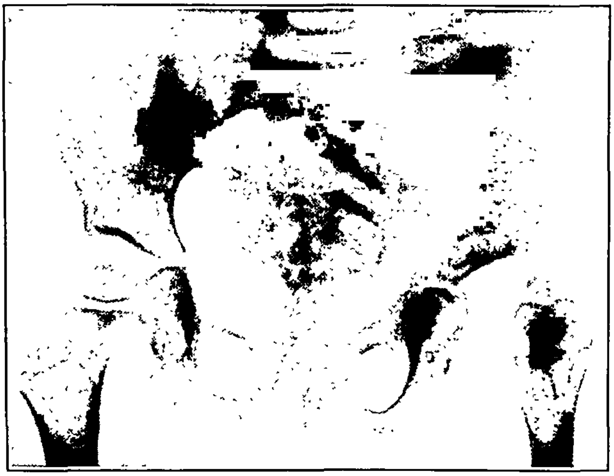

FIG. 10-D

Case 10. M. M. One year and three months after reduction. During this entire period, the hip was fixed in a plaster cast. This case illustrates the principle that if the head does not remain in the acetabulum after four months' fixation it may not do so even after prolonged fixation in plaster.

FIG. 10-E

Case 10. M. M. Eight months after reconstruction of the acetabulum.

When the hip joint is exposed at the time of operation it may be found that the head cannot be placed in the socket. Kidner, in 1931, called specific attention to the adherence of the capsule to the ilium above the socket and stated that he believed this condition to be the major factor in preventing reduction. In 1923, the author called attention casually to this condition, stating that "the capsule is then detached from the ilium from below the inferior spine backward", and he has always freed this attachment down to the very border of the acetabulum.

FIG. 11-A

Case 11. C. A., aged five years. Traction by a turnbuckle cast was employed.

FIG. 11-B

Case 11. C. A. One year after open operation to reconstruct the acetabulum.

However, he does not believe that this condition is necessarily the major factor in preventing reduction. In the author's experience, the major factor is a short neck or, even worse, a capsule that is attached to the femur at the margin of the articular cartilage. This condition not only prevents the entrance of the head into the socket, as is apparent at a glance, but it often renders it impossible to bring the head forward to the socket even though the head is on a level with the socket. In these cases the capsule must be completely detached from the femur and at times the neck of the femur must be elongated by transposing the trochanter downward on the shaft.

2. The acetabulum must be of sufficient depth to admit the entire head. If the head does not lie entirely within the socket, it is subluxated. Many roentgenographic examinations show that this condition becomes worse instead of better with the passing of time. The body weight is borne only on the inner portion of the head and the outer portion of the acetabular roof. The mechanical laws of the resolution of forces tend to thrust the head without the socket, and the acetabular roof tends to wear away under the abnormal pressure.

Various means are at our command to deepen the acetabulum. It frequently contains fat and fibrous tissue. This may be removed with a scalpel, curved scissors, or a sharp curved gouge. At times, the ligamen-

tum teres is so elongated and thickened that it blocks the entrance of the head. In such cases it must be excised. The inferior capsular fold enters the socket as the head is approximated to the acetabulum. Many writers state that this fold must be incised or cut away. The author has found that usually he is able to push it down out of the way as the head is reduced. This cannot be done when the neck is too short, as described in a preceding paragraph.

FIG. 11-C

Case 11. C. A. Seven years after operation. There is present one-half an inch of shortening, but motion is almost normal. The patient suffers no pain and leads a normal life.

The acetabulum in itself, apart from the soft tissues, may be too small to admit the head. Some surgeons ream out the acetabulum until it is large enough. This method has its dangers,—chiefly consequent stiffness or bony ankylosis. Colonna tries to prevent limitation of motion by covering the head with a layer of the capsule. Some years ago, the author lined a bony socket with a covering of fascia, but discontinued this method because of unsatisfactory results. A capsular or fascial covering of the head partially fills the socket and prevents complete reduction.

The author prefers to leave the acetabular cartilage intact except very occasionally when he pares it off slightly but does not expose the underlying bone. The socket can always be enlarged sufficiently by throwing down a neat and close-fitting shelf along its superior and posterior margins, and, at the same time, reflecting the entire acetabular roof downward to correct obliquity.

On two occasions, the writer performed an open reduction and placed the head in an acetabulum that seemed to be sufficiently deep to hold the head. These hips redislocated. Since that time, he has returned to his original practice of shelf formation and reflection of the roof in all open reductions.

3. The roof of the acetabulum must be neither so defective nor so oblique as to permit the head of the femur to slip out from beneath it, either suddenly or through a period of years. In reviewing his own cases in which relapse has followed bloodless reduction, the author has frequently seen the untoward result of this acetabular obliquity.

It is the writer's belief that an oblique socket makes an oblique head

inevitable during the period of growth, and that, in this instance at least, *the head is molded to fit the deformed socket.*

This defect may possibly be corrected by *reaming out the socket* to make it deep enough and its roof sufficiently horizontal. This statement implies that there is sufficient bone at the acetabular site to permit this purpose to be accomplished. The author believes that in many cases there is not this sufficient thickness or depth of bone. In the second place, articular cartilage is thereby removed which is probably never replaced, and a joint is thus constructed which is, at least in this respect, not a normal joint. If we avoid fibrous or bony ankylosis by some such method as that of Colonna we still have a joint that is like an arthroplastic joint, serviceable, possibly, for a time or for many years, but lacking always in at least one of the elements of a natural joint.

Therefore, it still appears to the author more rational to correct this acetabular obliquity by reflecting the roof downward and maintaining it in this correct position by bone wedges driven in firmly above it. Thus, by a plastic bone operation, the socket is reformed, so that it forever resists the upward thrust of the head. The author clearly described this procedure in an article published in 1928. It may be said in passing that many of the poor results of the bone shelf that have been reported in the literature and which have been observed by the author in numerous clinics seem to be due to neglect of the surgeon to carry out this procedure.

Nové-Josserand, in 1933, published a method of correcting acetabular obliquity by detaching the articular cartilage from the roof, reflecting it downward, and filling in the space with bone wedges or chips. The author's method appears more rational for these reasons: it is an integral part of the shelf operation whereby the acetabulum is made large enough to contain the entire head; the enlargement or deepening of the acetabulum is essential in most, if not all, cases that require open operation; the acetabular roof has an even and unbroken flow outward from its inmost portion to the very margin of the shelf, and thus hugs closely the entire upper portion of the head; and, finally, the natural contiguity of the articular cartilage with its underlying bone is not destroyed even temporarily.

PALLIATIVE OPERATIONS

Palliative operations are performed not with the expectation of constructing or of enabling nature to construct a hip joint normal in all its structures and its functions, but with a reasonable hope of lessening, relieving, or preventing the untoward consequences of irreducible dislocation. The severity of these consequences, naturally, must be vastly different in individuals according to age, body weight, physical activity necessary to their usefulness or pleasure in life, the degree of the deformity itself, and whether the dislocation is bilateral or unilateral. These patients may suffer pain in the hip and in the back, they limp, and they may tire easily and be unable to engage in any pursuits of life that require

them to be on their feet. Their disability may be so great that they are confined to the house a large part of the time. On the other hand, there are some women with bilateral dislocation of the hip who reach middle adult life without pain and disability.

Palliative operations are performed largely on individuals more than five or six years of age, but the author has seen children under this age with such marked deformity of the hip that there could be no hope of constructing a normal joint.

These operations are designed to secure one or all of the following results: relief of pain, reduction of the shortening, lessening of the limp, stability, and preservation of motion. Many operations have been invented to accomplish these objects, but present orthopaedic practice has virtually confined itself to two methods,—an osteotomy of the femur or a plastic construction of an adequate acetabulum by means of the so called "shelf operation".

Osteotomy

The methods of osteotomy which are most commonly employed are those of Lorenz, von Baeyer, and Schanz. The author has had no experience with osteotomy because he has always believed that the construction of an adequate acetabulum is sounder surgery in that it more closely approximates nature's method of weight-bearing and locomotion at the hip joint.

The high osteotomy of Lorenz, whereby the sharp distal end of the femur is thrust inward to make contact with the side of the pelvis, appears to rely for its success largely on the fact that a new point of weight-bearing is formed. If through this new contact some or all of the body weight is transmitted to the leg, then the dislocated head of the femur is relieved in part or in whole of this function which it performs inadequately of itself. However, if the large head of the femur cannot sustain the body weight, how can the smaller spicule of the shaft do so unless it comes in contact with the pelvis beneath some ledge or in some concavity which may receive its thrust? If there were some remnant of the original acetabulum into which the upper end of the distal fragment of the femur could be thrust, then one could understand the mechanics of the operation. The author has frequently observed in old congenital dislocations that there is nothing left of the original socket.

The low osteotomy would appear to depend chiefly upon another principle. The femur is bowed inward many degrees at the level of the lower margin of the pelvis. The upper fragment, therefore, is widely abducted and the pelvis is thereby tilted upward on the opposite side. The weight of the body is transmitted to the extremity along an inclined plane instead of on the end of the upright femur. By this arrangement, in accordance with the resolution of forces, more of the upward thrust of the femur is transmitted to the pelvic bones and less to the soft structures which bind the femur to the pelvis.

If the high bifurcation operation also secures wide abduction of the upper fragment of the femur, then one can comprehend its usefulness. The author commends the sane and rational paper published last year by Gaenslen on the Schanz subtrochanteric osteotomy in which the advantages and the disadvantages of this procedure are enumerated. It must be borne in mind, however, that the soft structures of the hip are still bearing an undue strain in that they alone are preventing the pelvis from slipping downward off the inclined plane. It is conceivable that this might lead in time to a recurrence of the pain and fatigue which have been relieved by the operation.

Reconstruction Operation

The reconstruction or shelf operation dates back to König in 1891. He is said to have operated on two children, one of whom died of diphtheria and one of scarlet fever. Its wider use began in this country in 1923 when Dickson read his original paper on this subject. It may be said here, merely as a matter of record, that the author began in 1919 to operate on old irreducible dislocations, but it was not until 1921 that he had evolved the substantial portion of his technique of the shelf operation. In discussing Dickson's paper in 1923, the writer reported nineteen operations on the hip. The author prefers to call the operation "plastic construction of an acetabulum", as the formation of a "shelf" is but part of the operation.

Many of these operations have been done in recent years in numerous clinics both in America and abroad. They have been attended with sufficient success to establish this surgical procedure as one that is definitely and widely useful. Both in the author's experience and in that of others there have been failures to accomplish all the good results that we hope or believe to be possible. Some of these failures have indeed been dismal. The author's worst failures occurred in his early experience before he understood clearly all the factors that make for success, and when he had nothing but his own experience to guide him. Perhaps there has not been sufficient time to evaluate the complete and final results of this operation. It may be that in years to come a disabling arthritis will develop in some of the patients upon whom this operation has been performed as has been predicted by one critic. We must agree, however, that such an event is less likely to occur in a joint which has been made more like a normal joint than it was before. In any event we have secured for our patient at least a few good years free from pain and full of usefulness.

The principles to be observed in this operation are, at least in part, as follows:

1. The new acetabulum should be placed as near the original one as possible.

Preliminary traction, as described in a preceding paragraph, has been found to be useful in drawing the head downward. Its success varies with the rigidity of the hip.

At the time of operation the head of the femur should not be forced and pried downward into a socket.

During the operation the head should be delivered from the capsule except in cases of subluxation when it rests partly within the original

FIG. 12-A

Case 12. L. B., aged forty-five years. The patient complained of severe pain and had marked disability.

FIG. 12-B

Case 12. L. B. Two years after reconstruction operation had been performed high on the ilium. The patient has no pain, is able to walk long distances, and leads a normal life.

socket. The head is brought forward to the anterior margin of the pelvis, and the femur is moderately abducted. The new acetabulum is constructed at that point where the head then rests against the ilium.

2. The new acetabulum should be made as nearly like a normal one as possible.

A rounded excavation is made in the ilium into which the head fits. Even when the excavation is made high on the ilium where the bone is thin, the femur will not slip upward if it is kept abducted. Once the shelf is constructed, the femur must not be allowed to slip lest the shelf be broken down.

The head is placed in this excavation to determine whether it fits it neatly and will remain in it on abduction of the femur, and is then removed and held out of the way while the bone flap is turned down from the outer table of the ilium.

The flap, semicircular in shape, should be wide enough to cover the cartilaginous head. Its base should not be more than one-fourth to three-eighths of an inch from the round margin of the excavation. It should be detached and bent downward and forward gently and carefully so as not to break it off. If it is done carefully, this flap may be bent downward more than 90 degrees even in an adult.

The head is then replaced in its bed and the shelf bent further until it hugs the head closely above and behind.

If the ilium is sufficiently thick, as it is at or below the inferior spine, the osteotome should then be driven into it almost at a right angle immediately above the bed in which the head lies. The roof of the socket is then pried and reflected downward, as described in the earlier part of this paper.

Wedge-shaped pieces of bone are then driven firmly into the cleft made above the roof of the socket. They project above the shelf and hold it firmly in contact with the head.

If the socket is made high on the ilium, wedges cannot be driven into it because of its thinness. In such a case, the space between the shelf and the ilium is packed with small pieces of bone removed from the excavation and from the side or crest of the ilium.

The margin of the capsule is then brought up over the free edge of the shelf. It will be observed that this holds the shelf down firmly against the head of the femur.

The gluteal muscles are sutured to the crest. They also maintain a pressure on the shelf and the bone fragments above it. The wound is closed and a plaster cast is applied with the femur in sufficient abduction to keep the head of the femur from slipping upward.

One of the author's patients complained of the sharp crest of the ilium following operation. Since then, in young individuals, the author has incised the base of the cartilage that forms the crest, turned the cartilage upward and inward without detaching it from its overlying fascia, removed the bone wedges, and sutured the cartilage in place again

on closing the wound. Thus the smooth round crest of the ilium is preserved.

3. There should be no abnormal pressure on the head of the femur within the socket.

4. After-treatment is directed toward increasing the mobility of the hip joint and strengthening the muscles which move it.

As soon as the stability of the new socket permits, as it does in four to six weeks, the cast is removed and Buck's extension is applied. Baking and massage and active and passive motions are begun and continued. The child is allowed to bear weight gradually after twelve weeks, but physical therapy and exercises are continued for as many months as may be necessary to complete the functional cure.

The poor results from the shelf operation which the author has observed or has seen reported in the literature appear to be due to violation of the principles enumerated in the preceding paragraphs. The causes of these failures may be summarized as follows:

1. If the head of the femur is not moved forward to the anterior margin of the pelvis, the lumbar lordosis is not corrected and the gluteal muscles are not restored to activity. Trendelenburg's sign may be present.

2. If the shelf is formed too high above the acetabulum and is not an integral part of it, the head will slip out of the socket and rest beneath the shelf which may then be broken down or may be absorbed. The shortening of the extremity is increased.

3. If the bone flap which forms the shelf is turned upward from the ilium instead of downward, the operation is manifestly more difficult and the acute-angled space in which the head of the femur is placed in no way resembles the shape of a normal acetabulum. Likewise, tibial grafts driven into the ilium may provide a strong ledge beneath which the head of the femur securely rests, but they cannot be molded to embrace the head as does a normal acetabulum. Why should not the head flatten itself to fit the ledge rather than that the ledge should round itself to fit the head?

4. Stiffness and ankylosis are probably due to excessive pressure within the acetabulum and too prolonged fixation in plaster.

The question of abnormal development of the head of the femur, such as Legg-Perthes disease, as it complicates the treatment of congenital dislocation is very important, but is beyond the confines of this paper. However, it seems pertinent here to call attention to the fact that many cases of Legg-Perthes disease are marked by a shallow and oblique acetabulum. The observations of Murk Jansen and others are well known. If the surgeon should reconstruct this faulty socket by making a bone shelf and by reflecting downward the acetabular roof, might he not prevent the development of Legg-Perthes disease of the head or aid in its cure if it is already present? Furthermore, is the presence of Legg-Perthes disease in a congenital dislocation, whether before or after bloodless reduction, sufficient evidence to conclude that the hip is not amenable to successful closed or open reduction?

SUMMARY

1. Predislocation and dislocation in infants, discovered by examination soon after birth, may be cured in a high percentage of cases by the abduction method of treatment.

2. After the beginning of the walking period of life, bloodless reduction by gentle manipulation should be tried in all favorable and border-line cases.

3. In many cases the dislocation appears clinically to be reduced by the manipulation, but in subsequent months and years it is discovered that subluxation or luxation has occurred or that serious structural abnormalities cause pain and disability of the hip. With the aid of the rules laid down by the author, it is possible in many cases to determine soon after the bloodless manipulation whether or not the hip may be expected to become normal both in structure and in function.

4. If manipulation is unsuccessful, open operation should be performed.

5. At every open reduction an attempt should be made to correct the obliquity and the shallowness of the acetabulum if these conditions are present, as they very frequently are.

6. Palliative operations should be performed in cases of irreducible dislocation to eliminate or reduce as much as possible the symptoms of pain and disability or to prevent their development. In such operations, no attempt is made to restore the normal anatomy of the hip.

7. The osteotomies of Lorenz and Schanz are undoubtedly useful in selected cases.

8. The reconstruction of an acetabulum, or the "shelf" operation, if properly performed, has proved to be a very valuable procedure in almost all cases.

CONCLUSION

The author has attempted to present a rational and practical working basis for the treatment of congenital dislocation of the hip. The time limit set upon this paper forbids anything approaching an exhaustive dissertation upon this vast and voluminous subject. Different surgeons may have their own methods and devices, but they must not depart from fundamental principles if they would attain success.

It appears to the author that the educative work undertaken by Putti to further early diagnosis and treatment is the most important recent development in the treatment of congenital dislocation of the hip.

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AN APPARATUS FOR CORRECTION OF SUBLUXATION OF THE TIBIAL HEAD

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This paper presents a brief description of an original piece of apparatus used for correcting a posterior luxation of the tibia on the femur. The apparatus is not complicated and can be made without any expensive outlay of material or time. At the time when this paper was written, this apparatus had been used satisfactorily in only one case resulting from a burn contracture about the knee joint.

CASE REPORT

W. W., a child, came into the hospital with a flexion contracture of the knee resulting from severe untreated burns about the knee, especially on the posterior surface. The flexion deformity was corrected by resecting the scar tissue and by applying tube grafts to the defects, followed by wedging leg casts and skin traction. When the leg was in full extension, it was noticed that there was considerable deformity about the knee, due to a well-developed subluxation of the tibia on the femur. After traction and casts had failed to correct this deformity, a capsulorrhaphy was performed and appropriate postoperative treatment was given. In spite of this procedure, the deformity still remained (Fig. 1).

On February 8, 1935, Steinmann pins were inserted in the lower end of the femur and the upper end of the tibia away from the epiphyseal lines. The pins were placed so that more of the shaft would be on one side than on the other, in order that the balance would be on the side against which the force of the pins would be directed. After appropriate dressings had been fitted to the pins, a short, heavy cast was applied around the thigh to act as a buttress against the force exerted by the upper arm. A transverse bar

FIG. 1

Roentgenogram showing the knee joint following capsulorrhaphy and before applying the rotation-distraction device.

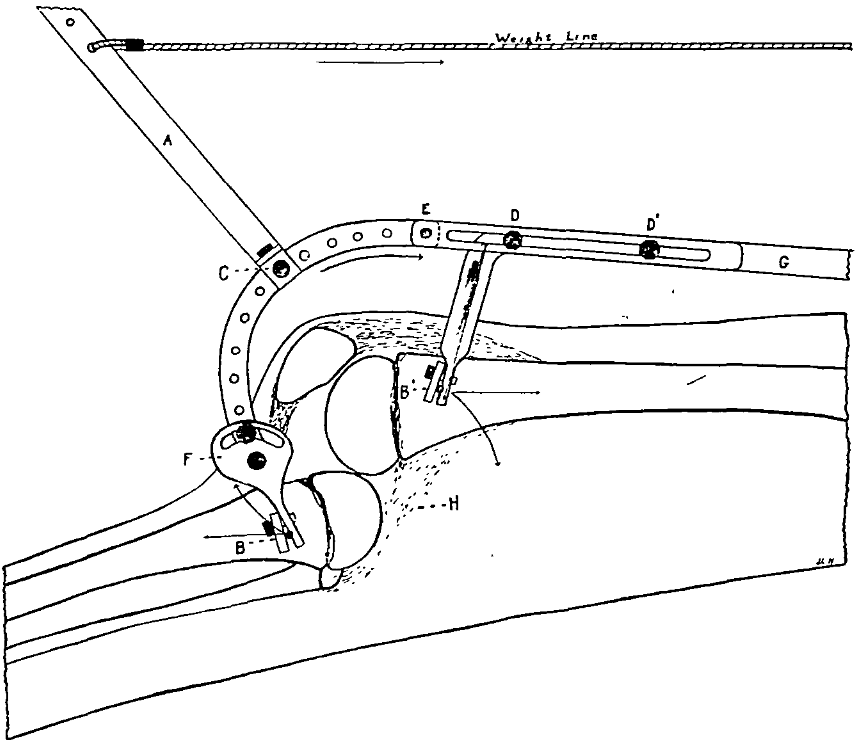

FIG. 2

Diagram illustrating rotation-distraction apparatus as applied to the knee joint. All parts of the apparatus are paired with the exception of the upright traction bar, *A*.

The two sections are tied together by their grasp on the Steinmann pins, *B* and *B*[1]; the U-shaped adjustable base of the traction bar, *C;* and through-and-through adjustable bolts, *D* and *D*[1]. The distance between *B* and *B*[1] may be varied by adjusting slot *DD*[1] and (or) arm *F*, with consequent increase in amount of distraction. The lower section of the apparatus rotates around the axis, *E*. Arm *G* is strapped to a short spica or leg cast. Arrows indicate the direction of corrective forces. *H* indicates marked thickening of the capsule in the case reported.

was incorporated in the cast dorsally to give stability to the part. If it is desired, a short spica may be used instead of the leg cast, thus obviating the necessity of strapping the cast to the frame to prevent the leg from riding upward as a result of the action of the weight upon the unfixed hip. The rotation-distraction apparatus (Fig. 2) was attached to the pins and the weight line was strung to an overhead frame.

Starting with two pounds, the weight was gradually increased to eight pounds. At no time was there marked discomfort to the patient. Fifteen days after application of the apparatus, roentgenograms showed the subluxation well corrected and the condyles of the femur and tibia well separated (Fig. 3).

Since it was felt that the capsule was thoroughly stretched, the apparatus and the Steinmann pins were removed. This was followed by the application of a snugly fitting leg cast with the leg in complete extension. A short time later, physiotherapy was instituted to develop the quadriceps muscle which had become stretched and weakened by the prolonged flexion and resultant disuse.

On March 31, 1935, approximately seven weeks after application of the rotation-distraction apparatus, the roentgenogram showed a satisfactory joint relation, and the child was dismissed wearing a walking cast. When the patient was last seen in the Clinic, function was quite good and the external appearance of the knee was much improved.

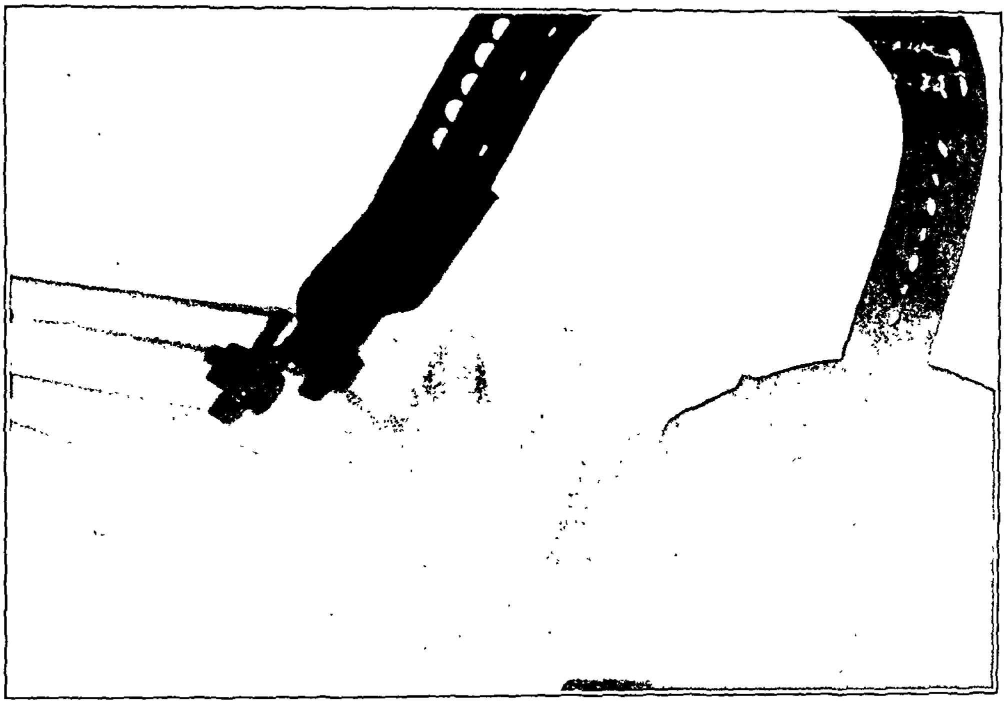

FIG. 3

W. W. Showing apparatus in place just before removal of the pins. Note separation of the joint surfaces.

SUMMARY

In the case of marked subluxation of the tibia described, correction was obtained by the use of an original piece of apparatus, employing rotation-distraction forces acting upon Steinmann pins in the lower end of the femur and the upper end of the tibia. The apparatus is workable and practical for similar conditions. Its use is also suggested in the treatment of anterior displacements of the tibia on the femur by applying it in the reverse position.

The author wishes to express thanks to Dr. William M. Roberts, Chief Surgeon of the North Carolina Orthopaedic Hospital, for use of clinical material from his Service.

LOCALIZED OSTEITIS FIBROSA IN THE NEW-BORN AND CONGENITAL PSEUDARTHROSIS

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The rare occurrence of congenital new growths or cystic changes in the osseous tissues of the new-born was recently pointed out by Witting and Gillespie. These authors found three cases of congenital benign bone cysts reported in the literature and added a fourth case in which there was an area of destruction with fusiform swelling, extending from the middle third of the fibula to a point half an inch above the distal epiphyseal line. The irregular trabeculation noted in their published roentgenograms and the absence of cysts in two similar cases, the reports of which follow, leads the author to express the opinion that the case of Witting and Gillespie, which was not explored and studied microscopically, may have been localized benign osteitis fibrosa without cyst formation.

CASE 1. J. D., a male, aged two weeks, was a well-nourished and well-developed infant, born at the Chicago Lying-In Hospital on January 10, 1934. The maternal history and the prenatal course were normal. A swelling was found on the inner surface of the left lower leg when the patient was taken home from the Lying-In Hospital. This swelling, near the knee, was about the size of a pigeon's egg, and was firm, immovable, and apparently attached to the bone. The patient held the leg rigidly and objected to its being moved. No other abnormal findings were noted. Roentgenograms (Fig. 1), taken on January 23, 1934, showed a cystlike area in the upper half of the left tibia, which involved more than the lateral half of the diameter of the bone for a distance of approximately one-third of its length. The remaining cortical portion of the bone on the medial side had been fractured at the level of the center of the area of bone absorption or destruction. Blood-chemistry determinations, on January 25, 1934, showed the normal inorganic-phosphate content of 6.9 and calcium content of 9.6. Other laboratory studies were normal. The diagnosis was localized osteitis fibrosa of the left tibia with a solitary bone cyst.

An operation was performed on January 26, 1934, and a spindle-shaped swelling was found. A strip, one centimeter wide and four centimeters long, was cut from the periosteum, exposing a cavity filled with what looked like firm fibrous and granulation tissue. There was old blood at the site of a recent fracture through the remaining cortex. The fibrous contents were curetted out, the bony edges were chiseled off, and iodine was applied. The wound was closed without drainage and healed by primary intention.

The material from the bone defect was cultured, but no growth was obtained.

Roentgenograms, taken on February 12, 1934, showed progressive filling in of the lesion of the tibia, but the fracture line was still present. On March 12, 1934, roentgenograms showed evidence of union of the fracture. There was buckling of the shaft, however, with convexity to the medial side. On May 7, 1934, roentgenographic examination showed that the operative defect was filling in. The tibia was quite straight, when viewed in the lateral position, but in the anteroposterior view there was tilting of the proximal articular surface, accompanied by lateral bowing of the fibula (Fig. 2).

The bowing and swelling at the site of the lesion gradually increased. A roentgeno-

gram, taken in December, eleven months after the operation, showed refracture, re-absorption of bone, and enlargement of the cystlike lesion.

The patient was admitted to the hospital and a second operation was performed on December 12, 1934. A white fibrous mass which was partly ossified was found to occupy the site of the lesion noted in the roentgenogram. This mass was excised. No cysts or soft areas were found. A whole-thickness tibial graft was placed across the defect after the tibial bowing had been corrected.

Union followed this operation and there has been progressive improvement. Roentgenograms of June 17, 1935 showed solid bone union and satisfactory alignment (Fig. 3). When the

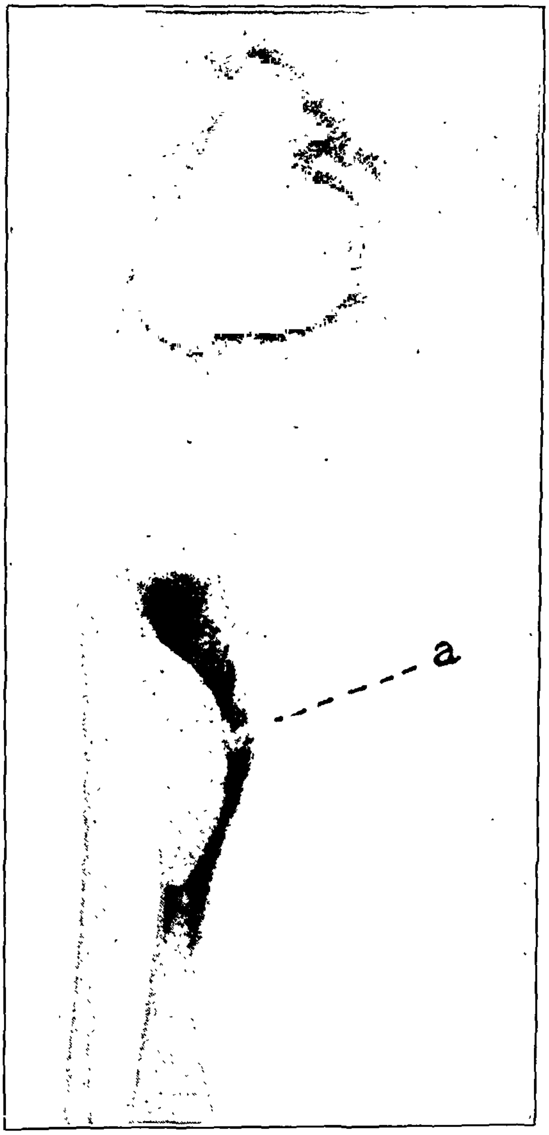

Fig. 1

Case 1. This roentgenogram, taken January 23, 1934, two weeks after the birth of the patient, shows the cystlike area in the proximal and middle thirds of the tibia with dissolution of continuity (*a*) in the remaining portion of cortical bone which bulges medially, suggesting new bone formation in an attempt to compensate for loss of bone laterally.

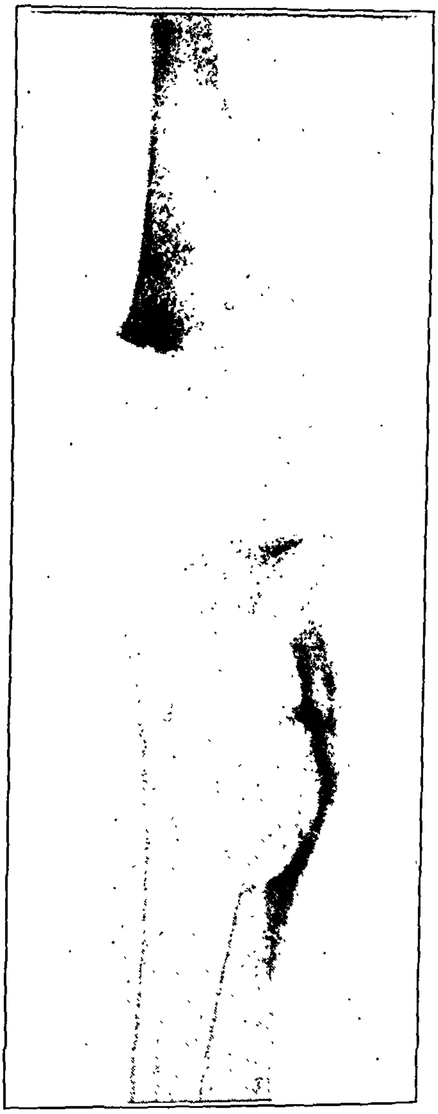

Fig. 2

Case 1. Roentgenogram, taken May 7, 1934, three and one-half months after the partial excision of the lesion. The cavity is beginning to fill in with new bone and the fracture has united. The tibia is bowed medially and seems to be proportionately longer than the fibula when compared to the roentgenograms of January 23, 1934. This bowing has produced a sloping surface of the upper end of the diaphysis of the tibia. Five months later, a roentgenogram showed extension of the lesion with refracture and non-union.

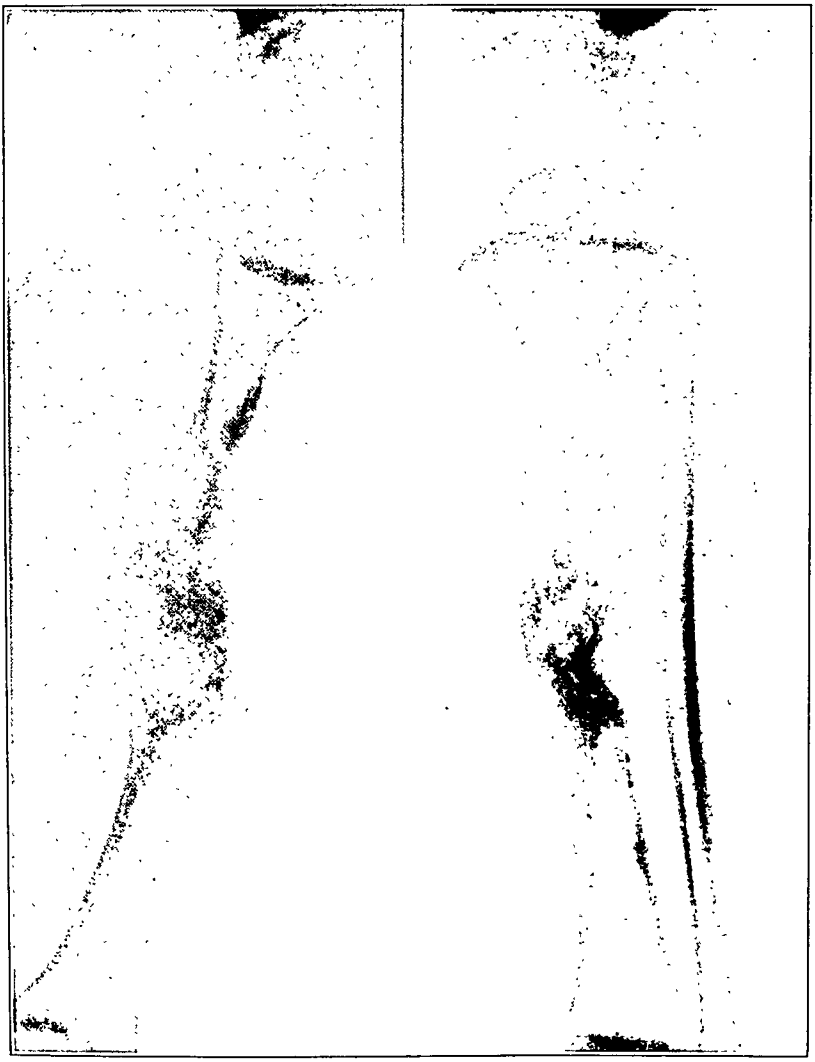

FIG. 3

Case. 1. Roentgenograms, June 17, 1935, seven months after the second operation. The ununited fracture which was present has healed, and there is no indication of recent bone absorption.

patient was seen in the Out-Patient Clinic on November 1, 1935, the legs were the same length, there was no curvature, and function was normal.

Pathology

The specimen removed at the first operation consisted of two pieces of cortical bone, a strip of periosteum one centimeter long and four-tenths of a centimeter thick, and small pieces of soft, reddish tissue from the central portion of the lesion.

Microscopic sections of a portion which included cortical bone showed bone trabeculae, osteoid tissue, and masses of rounded cartilage cells with dark-staining nuclei (Fig. 4-A). The marrow spaces were filled with dense fibrous tissue and the bone lacunae were lined with osteoblasts. The fibrous tissue within did not blend into the cartilage, but was sharply differentiated. The bone trabeculae extended into the cartilage mass and there were definite areas of cartilaginous new bone formation. In this section, there

FIG. 4-A

Case 1. Photomicrograph of a section of the tumor and fragments of cortical bone overlying the lesion. There is both new bone formation, as evidenced by the osteoid tissue (*a*) which is undergoing ossification and seems to be formed from either fibrous tissue (*b*) or cartilage cells present about it, and bone absorption, as evidenced by the lacunar spaces (*c*) which are lined with fibroblasts (*d*). The marrow is fibrous and vascular.

was both bone absorption and two types of new bone formation,—that from fibrous tissue to osteoid tissue or osteoid tissue formed by the fibroblasts lining the lacunae, and bone from cartilage. This cartilage may have been formed in the callus of the healing fracture. A few cystic spaces were noted in the cartilage mass.

FIG. 4-B

Photomicrograph of a section of the reddish material curetted from the lesion, which consists of dense fibrous tissue arranged in interlacing bands and whorls. Small spicules of bone (*a*) and areas of osteoid tissue (*b*) are noted. A few foreign-body-type giant cells (*c*) are scattered through the fibrous tissue and there are also round and plasma cells. Note the areas of cystic degeneration (*d*).

The section of reddish tissue curetted from the lesion consisted of dense cellular connective tissue arranged in interlacing whorls (Fig. 4-B). A few strands of osteoid tissue and small bone trabeculae were undergoing lacunar absorption. An occasional foreign-body type of giant cell was identified and round cells and plasma cells were

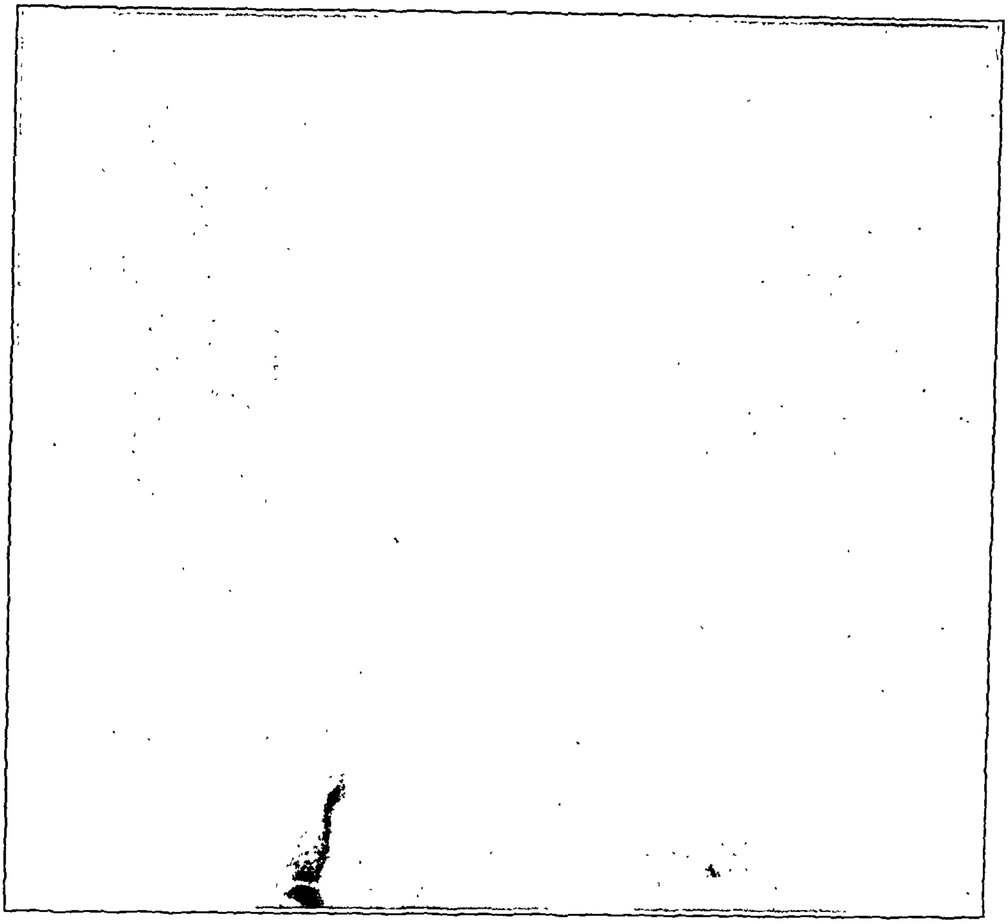

FIG. 5

Case 2. Roentgenogram of bones of both legs at the age of five months. There is a lateral curvature of both bones of the right leg. About five centimeters above the distal end of the right tibia, there is an ununited fracture through a cystlike area. The proximal end of the distal fragment appears to be articulating with the basket-shaped, slightly expanded distal end of the proximal fragment.

scattered through the fibrous tissue. Many small areas of cystic degeneration were noted.

CASE 2. H. M., a female. Two days after the birth of this patient, the mother had observed a "cracking, grating" sensation in the lower third of the child's right leg. When the child was between four and five months of age, the mother had noted that the right leg was bowed laterally and forward and that there was a visible and palpable swelling just above the ankle. A roentgenogram (Fig. 5) showed a defect in the right tibia and complete loss of continuity. The distal end of the proximal fragment was cupped and the distal fragment was articulating with it. The fibula was bowed laterally, but was not fractured. The family physician had operated and, after the removal of some "tumor" tissue, had stated that the lesion was a bone cyst. The leg had then been immobilized for approximately one year. At the age of fifteen months and again at the age of eighteen months, the leg had been "fractured" in order to correct the lateral and anterior bowing.

The patient was first examined in the University of Chicago Clinics on February 3, 1930, at the age of twenty-two months. She was not able to walk and, about two inches proximal to the right ankle, there was marked lateral bowing of the tibia and fibula; motion at this site indicated loss of continuity in both bones. A roentgenogram (Fig. 6) revealed the same cystlike expansion and central absorption of the shaft of the tibia proximal to the site of fracture that was present in the roentgenograms made at the age of

five months. In addition, there was an ununited fracture of the fibula at this level, with thinning or sharpening of the proximal ends of both distal fragments and complete dis-alignment and separation of the fractured ends. Some callus formation was noted about the fracture of the fibula and a lesser amount about the tibia.

The patient was operated upon on February 5, 1930. The cystlike area was found to be filled with fibrous tissue and callus. The fragment ends of the tibia were freshened and the bones aligned. A full-thickness bone graft, five inches in length, cut from the crest and the anteromesial surface of the tibia, was divided in the middle and one graft was placed on the mesial side and the other on the lateral side of the tibia, extending across the defect. (See Figure 7.)

Non-union resulted, with refracture of the lateral graft and absorption of the lower half of the mesial graft, and a second operation was performed on October 6, 1930. Intermedullary fibrous callus was curetted out and four full-thickness bone grafts from the left tibia were inserted so that they almost completely surrounded the right tibia at the site of fracture.

Microscopic sections of some of the material removed from the site of the non-union showed very cellular fibrous tissue with some callus and new bone formation.

Following the second operation, solid bony union occurred. A roentgenogram (Fig. 8), taken December 15, 1933, showed union and regeneration of the shafts of the tibia and

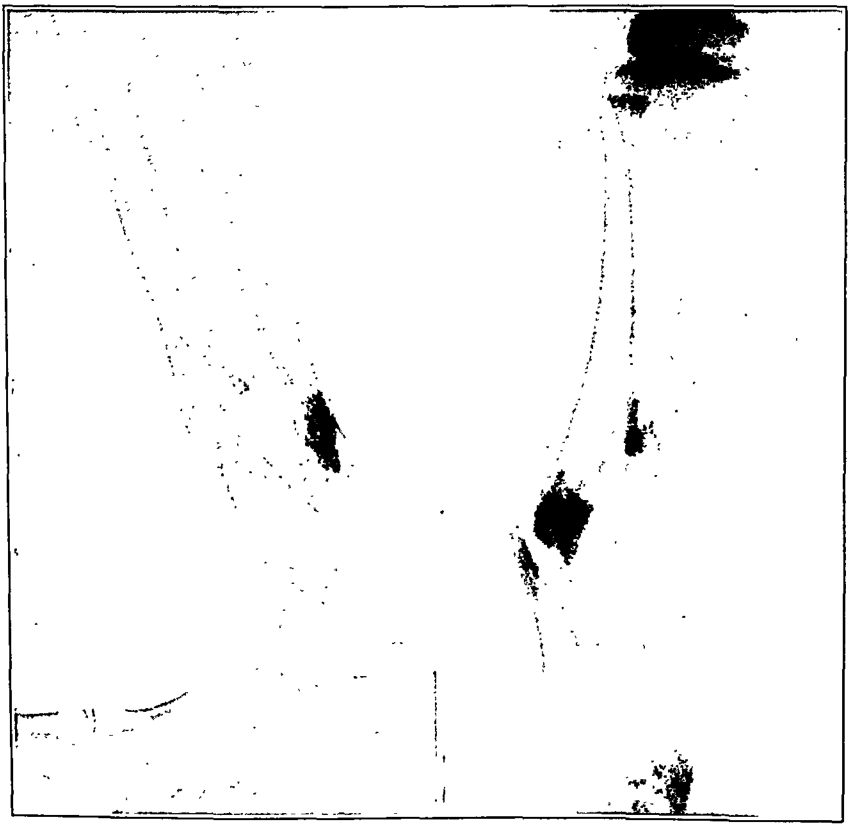

FIG. 6

Case 2. Roentgenograms, February 3, 1930, when patient was twenty-two months of age. There is a faint callus, but the fracture of the tibia has not united, the deformity has increased, and there is now an ununited fracture of the fibula.

the fibula. There was no narrowing of the epiphyseal line or other indication of growth arrest.

DISCUSSION

Cases of benign solitary bone cyst in the new-born have been reported by Stierlin, von Beust, and Frangenheim, as well as by Witting and Gillespie. On the basis of histological examination, Stierlin, von Beust, and

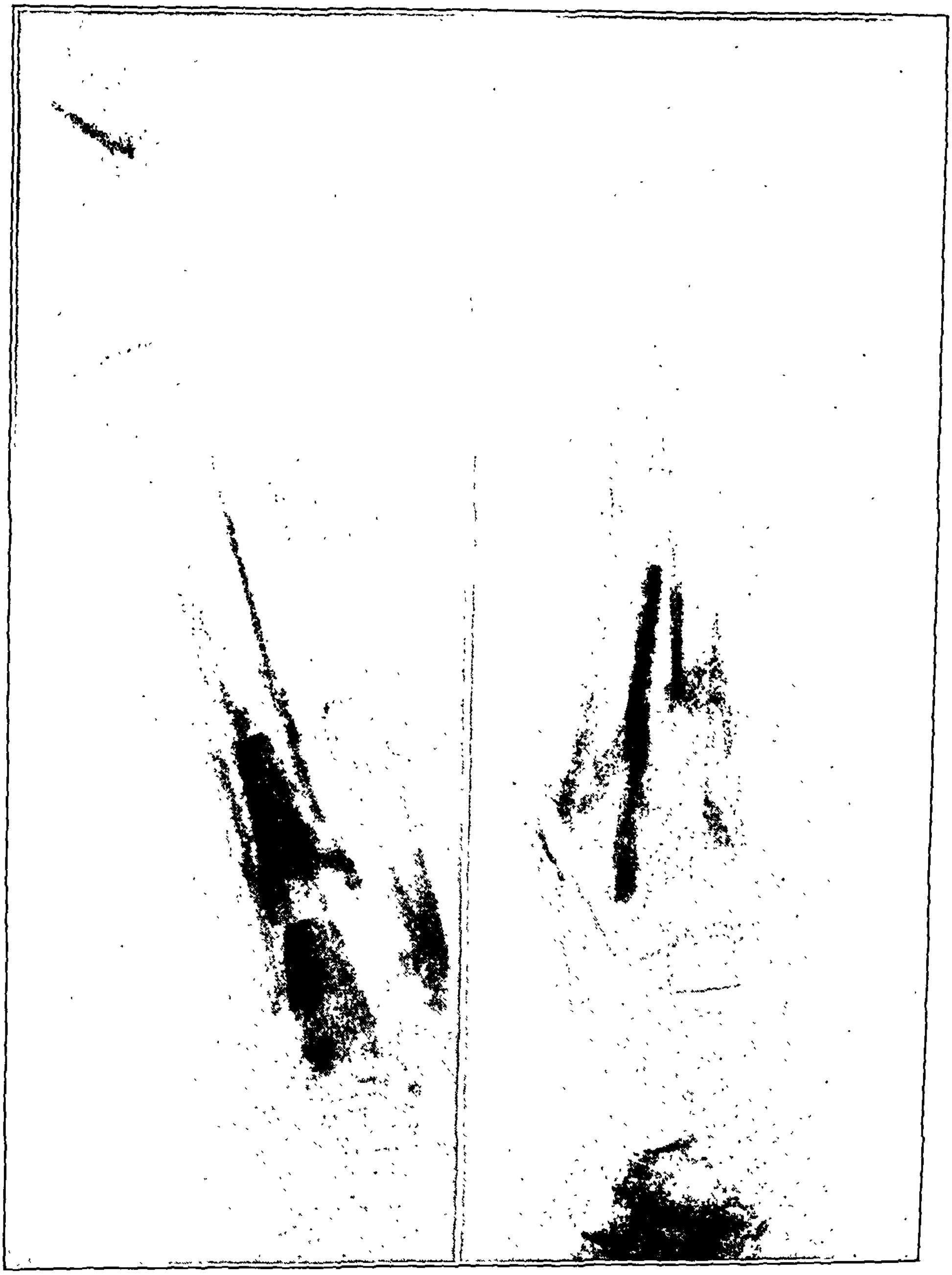

FIG. 7

Case 2. Roentgenograms, taken one month after an open reduction and insertion of two full-thickness onlay grafts, showing evidence of beginning union. Subsequent roentgenograms showed that one graft was absorbed after failing to unite and the second graft fractured. At a second operation, eight months after the first, four full-thickness grafts were used and union was obtained.

Frangenheim believe that cystic disease of the bone is the underlying condition in pseudarthrosis. Inglis and Camurati report that in their histological studies of the lesions of pseudarthrosis there was little evidence of osteitis fibrosa cystica. Kaufmann states: "Bone cysts, usually pseudo-cysts, occur occasionally from softening of former dense tumors, particularly the typical chondromas, more rarely the centrally cystic enchondro-fibromas."

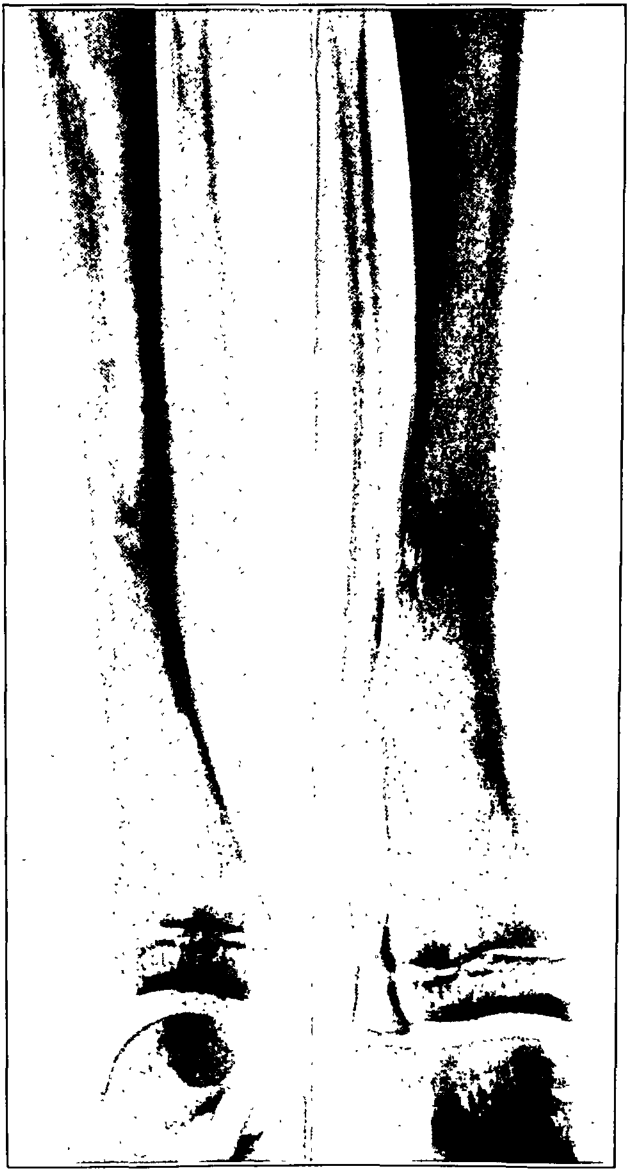

Fig. 8

Case 2. Roentgenograms, taken December 15, 1933, three years after the second operation, showing complete union of both the tibia and the fibula, good alignment, and regeneration of the cortex and medullary bone.

The tumor in the first case reported in this paper was composed of cartilage and fibrous tissue in about equal amounts, and there were small, almost microscopic cystic spaces in both the fibrous and the cartilaginous areas. Microscopically, this tumor could be classified as an enchondrofibroma with beginning cystic degeneration which might conceivably have led to the formation of a solitary bone cyst, and is evidence supporting the theory of Schlange. It must be remembered, however, that a fracture was present and the cartilage may have originated from the callus and not from the primary tumor.

The lesion reported by Witting and Gillespie was similar in roent-

genographic appearance to the two cases which the author has reported, but it was located in the fibula where congenital pseudarthrosis without involvement of the tibia is rarely, if ever, seen. The site of the lesion in congenital pseudarthrosis is usually in the middle or lower thirds of the tibia, as in Case 2, while the lesion which is described in Case 1 was in the upper third.

The fracture noted in Case 1 was recent, undoubtedly occurring either at the time of or shortly after the delivery of the infant, for at operation old blood was still present at the site. Both grossly and histologically, this fracture was similar to fractures occurring in bone cysts or localized osteitis fibrosa which are seen in young children in bones in which congenital pseudarthrosis does not occur or is quite uncommon. The healing of the fracture and the partial filling in of the defect within two months after the fibrous tissue had been cleaned out from the lesion is similar to that noted in other cases of localized osteitis fibrosa similarly treated in this clinic.

The postoperative reabsorption and refracture in both cases indicate growth and extension of the tumor tissue. Complete healing followed more careful excision of the fibrous tissue and insertion of tibial bone. In the older case it was necessary to operate a second time, using multiple full-thickness bone grafts in order to obtain permanent union.

SUMMARY

Of these two cases of solitary localized bone lesions, which were either congenital or occurred in early postnatal life, one was a case of localized osteitis fibrosa of the proximal third of the tibia and the other was a typical congenital pseudarthrosis in the lower third of the tibia. Both cases resulted in fracture and non-union.

Four similar cases have been reported in the literature. Three of these were described as cystic lesions. In the fourth case, there was no operative interference to demonstrate the presence or absence of cyst formation, and no fracture occurred.

In Case 1, bowing of the tibia was noted, suggesting that this lesion may have stimulated longitudinal growth from the proximal tibial epiphysis so that the tibia became relatively longer than the fibula and bowed, due to lack of support on the lateral side where the defect in the bone was most extensive.

Union was obtained, followed by normal function, through the use of full-thickness tibial bone grafts.

Each of these cases adds support to the contention of Stierlin, von Beust, and Frangenheim that fibrous or cystic disease of the bone is the underlying cause of congenital pseudarthrosis.

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PATHOLOGICAL DISLOCATION OF THE SACRO-ILIAC JOINT

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In a fairly thorough review of the literature, the author has not been able to find reported a case of a true pathological dislocation of the sacro-iliac joint. One case of congenital dislocation and many cases of dislocation of the sacro-iliac joint following trauma of various types and degrees have been reported. Because of the apparent rarity of this lesion, the author feels that it is worth while to record the following case which came under his observation.

Mrs. D., a white female, aged twenty-four, was admitted to the Gynecological Service of the Kings County Hospital on March 9, 1933, complaining of pain in the lower back. The patient stated that the pain in the back had started spontaneously about one week before admission and that she had first noticed it on attempting to turn. The pain had gradually become worse until she was admitted to the Hospital. She also gave a history of having fallen on her abdomen five weeks previously, at which time she was two months pregnant. This fall was followed by a slight bloody discharge, and abortion two weeks later. The patient had no chills or fever at that time, and had no medical attention.

Relevant physical findings on admission were: temperature 101 degrees, respiration 22, pulse 80. The patient was a pale, white female, well-nourished, well-developed, with a poor hemic component. The first heart sound was roughened and had a systolic blow. The abdomen was soft. There was tenderness over the symphysis pubis and a yellow discharge from the vagina. Also, tenderness over the left sacro-iliac joint was elicited on pressure.

The blood count showed:

White blood cells—9,800 per cubic millimeter
Polymorphonuclears—69 per cent.
Red blood cells—2,624,000 per cubic millimeter
Hemoglobin—55 per cent.

A roentgenogram, taken on March 15, 1933, showed an area of destruction at the lower part of the left sacro-iliac joint, and a displacement upward of the symphysis pubis on the left side.

Because of the continued sepsis and apparent absence of pelvic pathology, the patient was transferred to the Orthopaedic Service on March 16, 1933, with the probable diagnosis of suppuration of the left sacro-iliac joint. Traction was applied to the left leg on the same day, with marked relief of pain.

Because of return of pain and a continued temperature, another roentgenogram was taken on March 29, 1933. This showed essentially the same findings as the previous roentgenogram, except that there was an increase in the amount of destruction in the sacro-iliac joint.

On March 30, 1933, the sacro-iliac joint was opened from behind through a window in the ilium and sacrum, which permitted drainage of the pelvic cavity in which there was found a large accumulation of pus.

As the sacro-iliac joint was entered, it was found that the ilium moved very freely from side to side and up and down. It was actually a pathological dislocation upward of the entire os innominatum on the sacrum.

The wound was packed with vaselin gauze and the postoperative treatment was that usually employed for infections of the sacro-iliac joint. The temperature ranged from 99 to 105 degrees until April 11, 1933. From that date on, it gradually declined until it reached normal.

The patient was allowed up in a wheel chair on June 23, 1933. By July 10, 1933, the

FIG. 1

Shows riding upward of the entire left os innominatum at the symphysis and sacro-iliac joint. A postoperative defect, resulting from the drainage of suppurative arthritis of the sacro-iliac joint, is also shown.

wound had healed, and the patient was discharged, walking well and wearing a sacro-iliac belt. The belt was probably not necessary.

The patient was last seen in the spring of 1935 at which time she had had no recurrence and appeared and felt normal. A roentgenogram at this time showed fusion of the sacro-iliac joint with a small sequestrum at the site of operation, which was not causing any symptoms.

COMMENT

The author doubts very much whether the suppurative condition alone was responsible for the dislocation, because the os innominatum cannot slide upward on the sacrum unless there is also a separation at the symphysis pubis, so that we must have a loosening of both of these joints for the condition to occur.

This patient gave a history of having a spontaneous abortion a few weeks before the onset of the acute infection of the sacro-iliac joint. She was about two months pregnant at the time abortion occurred. We do know that, probably because of the action of some hormone, there is a relaxation of all the pelvic joints during pregnancy. However, relaxation of these joints takes place in a lateral direction. Because of the pre-existing physiological relaxation at the symphysis pubis, it is the author's belief that the coincident infection of the sacro-iliac joint, with resulting destruction in that joint, was responsible for the upward displacement of the os innominatum on the sacrum.

A MODIFICATION OF THE BALKAN FRAME

BY H. O. FOUCAR, B.A., M.D., LONDON, ONTARIO, CANADA
Chief of Surgery, St. Joseph's Hospital

For use in the average hospital, it is desirable that a Balkan frame be made as a single unit and of durable construction. It should be easily stored, transported, and set up ready for use with the essential accessories in place. It should, however, be adjustable in order that it may fit beds differing in size and be used on different types of patients. It should not necessitate the services of a special technician, but should be easily handled by interns, nurses, or orderlies.

With these requirements in mind, the frame about to be described was constructed. It is seven feet long, four feet wide, and six feet, four inches high and may be made by any plumber.*

The following is a complete list of the material used to construct the frame shown in Figure 1:

58 feet of ½-inch galvanized water pipe (outside diameter, ⅞ of an inch);
  4 pieces, each 6 feet, 4 inches in length, threaded at each end (*CCDD*);
  2 pieces, each 7 feet in length, threaded at each end (*EE*);
  4 pieces, each 4 feet in length, threaded at each end (*ABFF*);
  1 piece, 2 feet, 8 inches in length, threaded at one end (*G*);
1 solid bar, ⅜ of an inch thick and 2 feet, 3 inches long, threaded at one end to fit ⅜-inch T piece (*G*);
6 ½-inch caps on ends of *E*, *C*, and *D*;
2 ½-inch elbows between *A* and *E*;
11 ½-inch T pieces; thread of cross limb is reamed out;
1 T piece, ½ an inch by ⅜ of an inch; thread of cross limb is reamed out;
7 1½-inch swivel pulleys;
7 metal rings, 1½ inches by 3/16 of an inch;
4 stove bolts and nuts, ¼ of an inch by 1½ inches;
2 light chains, each 2½ feet long;
8 leather straps, each ¾ of an inch wide and 19 inches long;
8 buckles;
16 saddler's rivets.

The important technical procedure is the reaming out of the cross limbs of all of the T pieces. The threads are removed, so that these T pieces may slide along or rotate around the straight bars to which they are attached. By studying Figure 1, it is not difficult to see how the frame is assembled. The uprights and cross pieces are constructed first; the rings and pulleys are placed in position; the long horizontal bars are then added; and, finally, the ends are capped, so that the frame cannot be taken apart again except with a pipe wrench. To attach the pulleys, the rings are cut diagonally and are sprung to enclose the swivel rings of the

* The materials cost $13.00 at local retail prices and the labor, at ninety cents an hour, amounted to $5.00, making a total cost of $18.00. If these frames are made in quantities by hospitals, the cost would be even less.

pulleys. The leather straps are passed through the buckles for a distance of three inches and are then folded back on themselves. These short ends are fastened by two saddler's rivets to the other part of the strap, enclosing snugly the legs of the frame as illustrated in Figure 1. The foot uprights are perforated at intervals of four inches from the three-foot to the five-foot level to allow elevation of the cross piece. A chain is fastened by means of a bolt and nut to the lowest hole. To the other end of the chain is attached another bolt which may be inserted in any hole to maintain the required elevation.

Figure 1 shows the frame folded flat like a card table for storage or transportation. It weighs sixty pounds and can be carried by one man or, more easily, by two. Any objection to the weight is offset by the fact that the frame is carried as a single unit; there is no loss of time selecting parts or making multiple trips to the store-room.

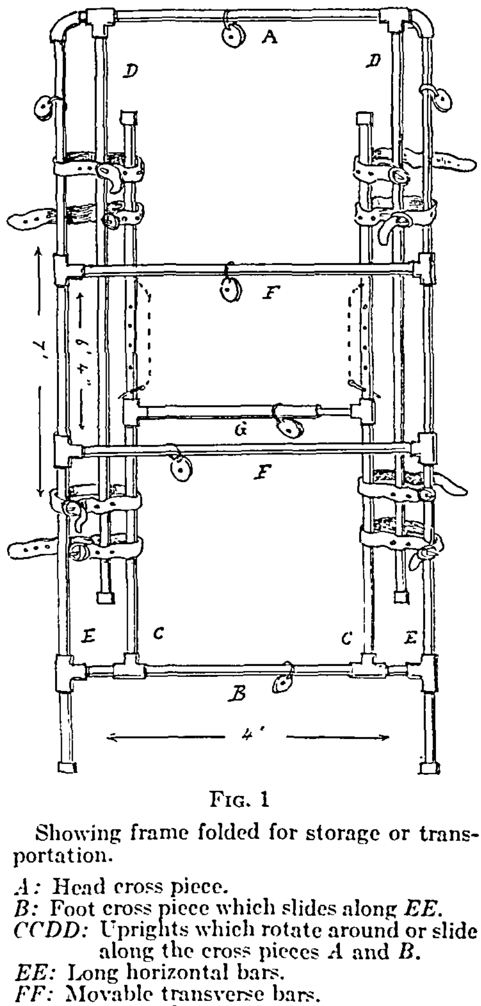

Fig. 1

Showing frame folded for storage or transportation.

A: Head cross piece.
B: Foot cross piece which slides along *EE*.
CCDD: Uprights which rotate around or slide along the cross pieces *A* and *B*.
EE: Long horizontal bars.
FF: Movable transverse bars.
G: Transverse bar on foot standard for extension of the lower limb.

The folded frame is placed flat on the floor beside the patient's bed; the foot end should be toward the foot of the bed and the legs should be underneath. For erecting the frame, two people are necessary, one at each end. The total time consumed is that required to loosen eight straps, to lift up the top frame, which allows the legs to fall down as in a card table, and to fasten these eight straps to the legs or bars of the bed. During this part of the procedure, the frame must be steadied, but once it has been firmly strapped to the bed it is stable. When the frame is no longer needed, the straps are undone, the legs are folded under and strapped, as shown in the diagram, and the frame is ready for storage. It will be noted that the foot cross piece (*B*) ends in T pieces which may slide along the long horizontal bars (*EE*). This is to allow the frame to fit beds of different lengths. The four uprights (*CC* and *DD*) also terminate in T pieces, so that they not only rotate around the

transverse bars (*A* and *B*), but also slide along them; thus the frame can be adjusted to fit the width of the bed. On the foot standard (*CC*) is attached a transverse bar (*G*) which is telescopic to fit beds of different widths and which may be raised or lowered for the purpose of extension of the lower limb at varying angles. The top frame is wider than the ordinary hospital bed. When the legs are firmly strapped to the bed, the whole top may occupy the midposition (Fig. 2, *A*) or it may be pushed well over to one side (Fig. 2, *B*) to allow suspension to the side of the frame of an arm or leg in abduction without the addition of any other piece to the frame itself. The cross pieces (*FF*) may also be moved merely by pushing them to the desired place; the new position is maintained by the downward pull of the weight applied, by simple friction, or by slight jamming of the cross pieces. To one of these may be fastened a handle for use as an overhead crane.

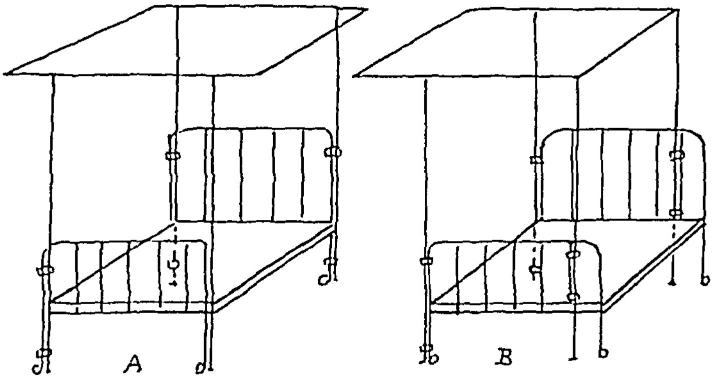

Fig. 2

Showing frame attached to bed.
A: Frame in midposition.
B: Top pushed to one side. Where greater distance is needed, the far uprights may be strapped to the bars of the bed instead of to the legs as shown.

Pulleys on metal rings are placed at suitable points. The ends of the pipe are capped to protect the floor and also to prevent the apparatus from being taken apart. The straps are of heavy leather and are riveted on each side of the uprights, so that they move up or down, but cannot slide over the caps. There is little excuse for the loss of a strap, because the only time it is touched is when the frame is actually being put up or taken down. At all other times the straps should be securely buckled. If a strap breaks it can easily be replaced. If heavy straps are used, this should not occur often because the strain is well distributed. The frame is made high enough to clear the heads of those caring for the patient, a minor detail but important nevertheless.

This simple and durable Balkan frame has been used by the author and has proved to be very efficient.

The author wishes to acknowledge the technical assistance of Mr. J. P. Bell, engineer at St. Joseph's Hospital, in the construction of this frame.

FRACTURE OF ANKYLOSED EXTREMITIES *

BY SIGMUND EPSTEIN, M.D., NEW YORK, N. Y.

The following cases reveal the unusual strength of ankylosed extremities in resisting fracture when subjected to accidental impact.

CASE 1. J. W., male, twenty-six years of age, had been operated upon in infancy for osteomyelitis of the right hip. A stiff hip and a seven-inch shortening of the limb were the sequelae. Due to an automobile accident on October 7, 1921, the patient was brought into the hospital with a severe injury to the right hip. A roentgenogram (Fig. 1) disclosed an ancient replacement of the hip joint by a dense mass of sclerosed, bony bridging. The acetabulum, femoral head, and most of the neck were missing. Beyond the fused area, an oblique fracture had occurred through the intertrochanteric line. There was slight outward displacement of the shaft. Under an anaesthetic, the limb was put up in slight abduction in a long plaster-of-Paris spica. At the end of seven weeks, the limb had been restored to its condition before the injury.

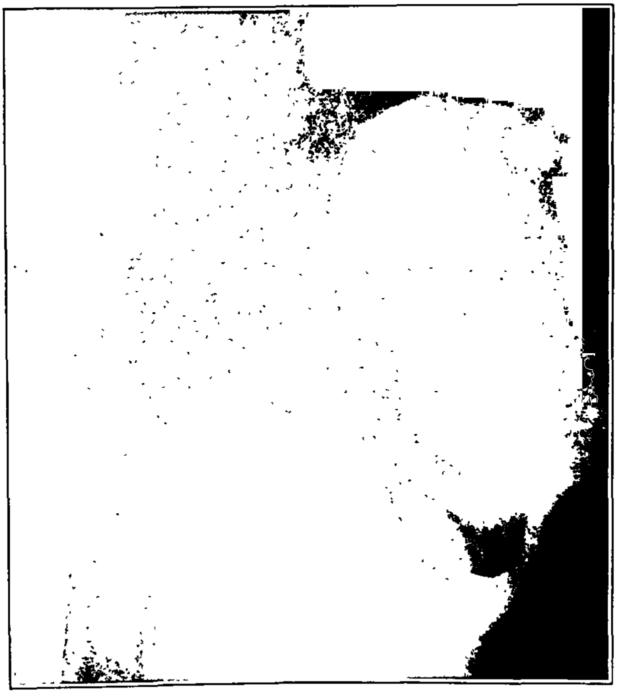

FIG. 1
Case 1. Fracture just below ankylosed hip.

CASE 2. J. S., a male, aged forty-two years, had had a stiff knee in the vertical position for many years. Then he fell down a flight of stairs, and was disabled immediately. He was admitted to the hospital wearing inadequate basswood splints and complaining of acute pain. Roentgenographic examination (Figs. 2-A and 2-B) revealed an irregular line of fracture running obliquely across the head of the tibia; there was no displacement of the fragments. Line tenderness, corresponding precisely to the fracture line, was noted. A plaster-of-Paris cast was applied from the groin to the ankle. The patient was soon able to walk and his stay in the hospital was short. At discharge, function was as good as before the accident.

CASE 3. E. W., a young female, had an elbow joint that had become ankylosed (90 degrees) as a sequela of an infectious arthritis. The patient fell subsequently and fractured the humerus across the condyles,—just above the line of the completely stiffened

*Presented at a meeting of the New York Physicians'-Yorkville Medical Society, New York, May 22, 1935.

oint (Figs. 3-A and 3-B). Immobilization in plaster-of-Paris resulted in a limb as useful as it was before the accident.

These cases are rare, and, at times, may be overlooked. Payr records that fracture through such bony ankylosis never occurs at the point of welding. In ankylosed knees, he observed fractures of the shaft of the femur, as well as of the shaft of the tibia. He describes a characteristic case of bony ankylosis of the knee, following tuberculosis, and shows a diagonal supracondylar fracture of the femur, ending above the region of the adductor tubercle. He also describes a shoulder ankylosis in which fracture occurred "in the neighborhood" of the rigidly ankylosed joint. In the American literature, fractures of the tibial shaft have been reported in ankylosed knees, following the removal of bone grafts.

Experience has taught that roentgenograms in two positions are indispensable. In Case 2, the injury was thought to be a ligamentous or muscular tear, as evidenced by the application of basswood splints before admission. The lateral view (Fig. 2-B) discloses four transverse lines of arrested bone growth in the shaft below the fracture. This condition has been described by Harris. A comminuted popliteal fragment can be seen posteriorly.

During the course of some arthroplasties for ankylosis, forceful

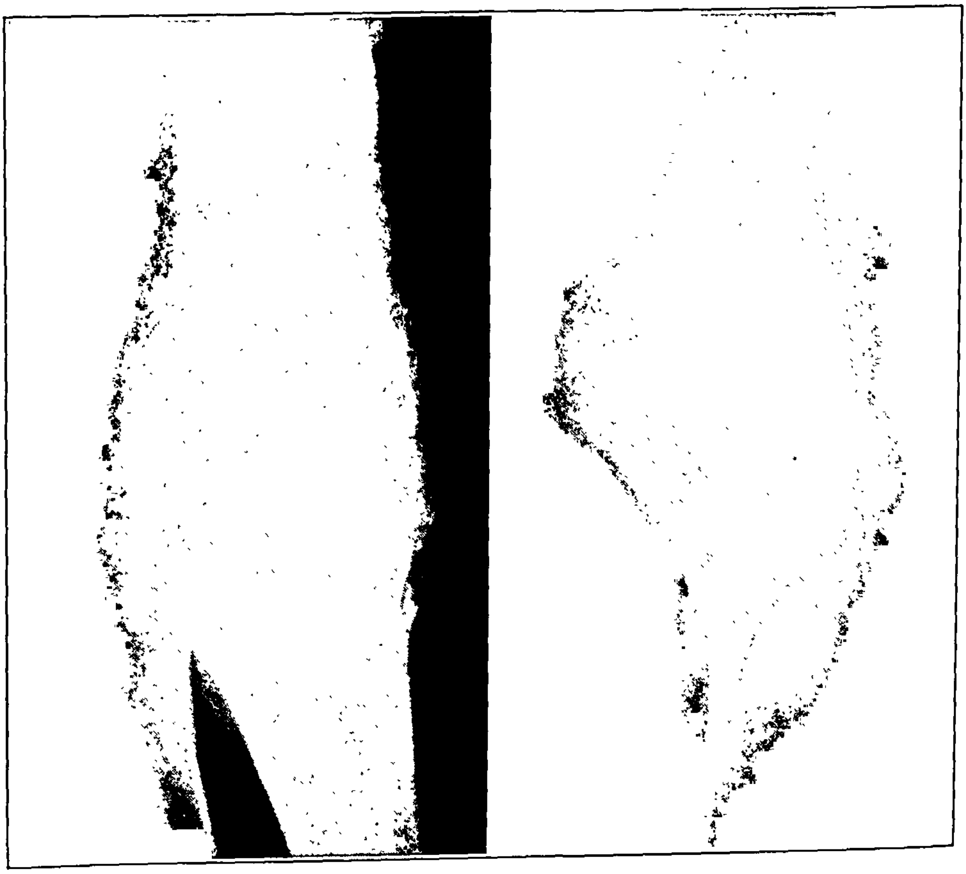

FIG. 2-A FIG. 2-B

Case 2. Anteroposterior and lateral roentgenograms of fracture just below ankylosed knee.

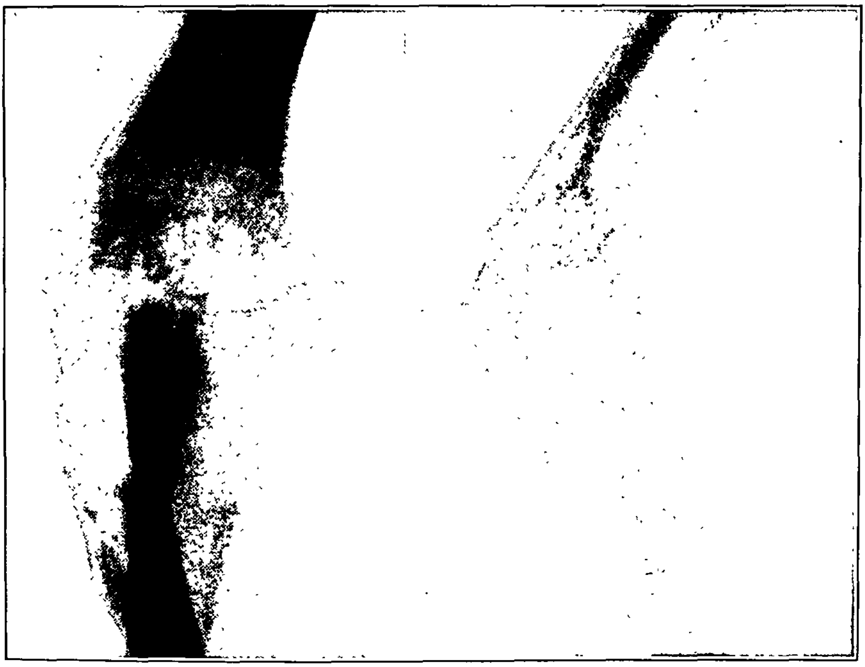

FIG. 3-A
Case 3. Fracture just above ankylosed elbow.

FIG. 3-B
Case 3. Lateral view of supracondylar fracture just above ankylosed elbow.

mallet blows upon the sharpest chisels barely chip these hard and firmly soldered joints, which clearly demonstrates why accidental impact has its breaking effect, not at the joints, but below them. A new surgical *neck*, in healthy bone, is the point of greatest weakness. The densest of these welded joints are found after purulent gonorrhoeal arthritis or coxofemoral osteomyelitis.

CONCLUSIONS

The completely welded, eburnated articulation of two long bones of the extremities, known as true ankylosis, is a mass of bone of great strength. If such bone is subjected to sufficient violence, fracture will result through an adjacent thinner juxta-articular segment.

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A METHOD OF ANCHORING KIRSCHNER WIRES

BY EDWARD N. REED, M.D., F.A.C.S., SANTA MONICA, CALIFORNIA

The accompanying drawings illustrate a method of anchoring the ends of Kirschner wires in tension bows, which has been found to be sure and effective, and also of simple, easy, and cheap construction.

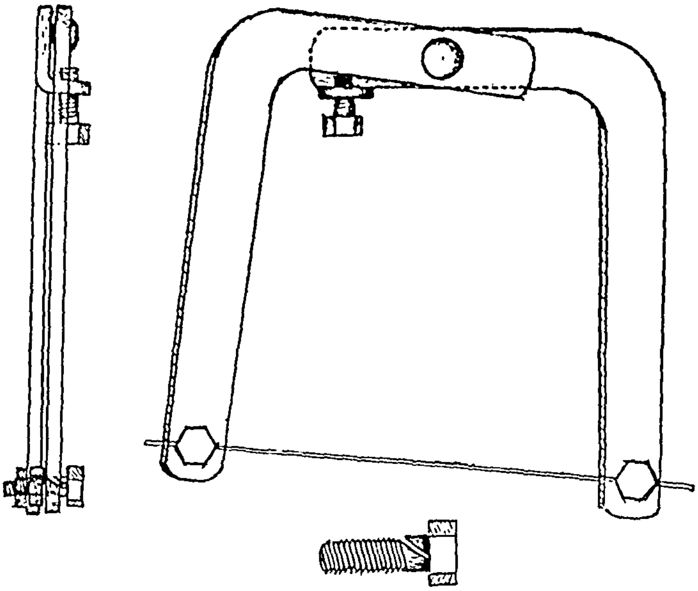

FIG. 1

The ends of the bows are drilled to take an ordinary machine cap screw. A screw, five-sixteenths of an inch in diameter and one inch in length, has been found to work well. The shoulder of the screw, between the head and the first thread, is sawed with a hack-saw diagonally from the outside to or a little past the center. By mounting two blades together in the hack-saw frame, a cut is made of sufficient width to accommodate the ordinary wire. (The author uses wires of a thickness of about fifty-four thousandths of an inch.) The wires are dropped into the slots in the cap screws and the nuts are tightened, using two wrenches. The slotted part of the cap screw is drawn down into the hole in the bow, which it fits snugly, and the wire is thereby locked so securely that no amount of tension can cause slipping. There is no need either for hardening of clips or for serrations to grip the extremely hard surface of piano wire. These locks can be made up in a few minutes at an expense of a few cents.

A COMMON CAUSE OF GENU VALGUM AND A SUGGESTION FOR ITS TREATMENT

BY R. M. YERGASON, M.D., F.A.C.S., HARTFORD, CONNECTICUT

For the past twelve or fifteen years, the author has frequently recommended the use of a home-made hobby-horse to correct the mild genu valgum which is so commonly seen in children and which is caused by riding an out-grown kiddie-car and pushing it along with the feet spread widely to the side. Numerous cures have been effected by this means in mild cases. The hobby-horse, shown in Figure 2, was made by the author and is not difficult to construct.

FIG. 1

The out-grown kiddie-car, which is too low, quickly causes genu valgum.

FIG. 2

A nail keg is a perfect body for the home-made rocking-horse, the use of which corrects genu valgum. No stirrups are used.

ERNEST MUIRHEAD LITTLE

JULY 26, 1854–OCTOBER 2, 1935

Orthopaedic surgeons all over the world will have read with regret of the death of Ernest Muirhead Little on October 2, 1935, at his home in Westminster at the age of eighty-one.

Born when orthopaedic surgery was in its infancy, Muirhead Little passed through the tenotomy phase and subsequently took a leading part in introducing Listerian principles in the open operative treatment of deformities. He qualified for the degree of Member of the Royal College of Surgeons in 1880 and became a Fellow of the Royal College of Surgeons in England in 1886. In 1888, he was appointed Surgical Registrar and later Surgeon to the National Orthopaedic Hospital, with which institution his surgical career thereafter became linked. In 1905, this hospital amalgamated with two other orthopaedic hospitals to form the Royal National Orthopaedic Hospital, and when the new building was opened Muirhead Little was appointed Senior Surgeon and Chairman of the Medical Board. In this capacity, he played a prominent part in the development of the hospital. By this time he had already become known internationally by his writings on congenital and paralytic deformities. His first publication, a small book entitled "Medical and Surgical Aspects of In-Knee (Genu-Valgum)", was written in conjunction with his father and appeared as early as 1882. From that time onward, he wrote steadily throughout his career and for many years rendered valuable service to the British Medi-

cal Journal by his writings on orthopaedic subjects and by the help which he gave to the editorial staff.

Early in the Great War he wrote a standard book on "Artificial Limbs and Amputation Stumps". In writing this book he incorporated the great experience he had gained during many years as Surgeon to the Surgical Aid Society and more recently as Surgeon to Queen Mary's Hospital for the war-disabled at Roehampton.

Even as long ago as 1876 he had acquired as a student a practical knowledge of military surgery, for he served in the Turco-Serbian war of that year and was awarded the Takova gold cross.

In what may be called clinical orthopaedics and the knowledge of its literature, Little was in his day almost unrivalled. He had a tenacious memory and could give references with amazing accuracy for particular papers in the literature; in this respect he was very approachable and would go to no end of trouble to satisfy the quest of those who appealed to him. He took great interest in the history of medicine and those who have read his "Glisson" will detect his literary gifts. His editing of the "History of the British Medical Association" for the Centenary Meeting of 1932 was widely commended.

Little received many professional distinctions. In 1894, he was elected a corresponding member of the American Orthopaedic Association. In 1913, when the International Congress of Medicine was held in London, he was Vice-President of the Orthopaedic Section, and the same year, on the formation of the Orthopaedic Subsection of the Royal Society of Medicine, he became its first President. In 1919, the British Orthopaedic Association also elected him as its first President, and, at the meeting of the British Medical Association in 1926, he was president of its Orthopaedic Section.

Muirhead Little was a man of natural charm and rare culture, beloved by his colleagues, his hospital patients, and all who knew him, and the profession has lost one of its most honest and sincere orthopaedic surgeons and a pioneer of singular modesty.

NOTE: *The Journal* is indebted to the *British Medical Journal* for the accompanying photograph of Mr. Little.

BRAINERD HUNT WHITBECK

JULY 20, 1877–MARCH 1, 1936

Brainerd Hunt Whitbeck died at his home in Bronxville, New York, March 1, 1936, after a long illness. He is survived by his widow, three sons, and one daughter.

Dr. Whitbeck was born in Rochester, New York, July 20, 1877. He attended St. Paul's School, Concord, New Hampshire, was graduated from Harvard College in the class of 1899, and from the College of Physicians and Surgeons of Columbia University in 1903. He served his internship in Bellevue Hospital.

During the World War he was an inspector in the Orthopaedic Service of the Eastern Division, and was commissioned a Lieutenant Colonel in January 1919. He was the first commander of the Leonard Morange Post, American Legion, Bronxville.

Dr. Whitbeck was Professor of Orthopaedic Surgery in the University of Vermont, and served for many years on the staff of the Hospital for the Ruptured and Crippled. He was Consulting Surgeon to the Roosevelt Hospital, Neponsit Beach Hospital for Crippled Children, Lawrence Hospital, Bronxville; Vassar Brothers Hospital, Poughkeepsie; and the Thompson Memorial Hospital, Canandaigua.

He was a member of the American Orthopaedic Association, the American College of Surgeons, the New York Academy of Medicine, and the Harvard Club.

All his life Dr. Whitbeck was handicapped by precarious health, but in spite of it he insisted on leading a most varied and strenuous existence. As his hospital appointments show, he travelled widely and almost continuously. Whenever possible he drove his car. Motoring he professed to be his favorite hobby, but it may be that he was thus making a virtue of necessity. He was a devoted husband and father, and took the keenest interest in following the careers of his boys in their college life, and in tennis, a sport in which they were exceptionally proficient. In fact, most of his enjoyments seemed to be of this vicariously domestic variety.

Dr. Whitbeck was one of the kindest of men, and the children in his various hospital services were devoted to him—always a good index of a man's character. He met the ups and downs of his professional career and the inroads of ill health with at least a perfect outward calm, although his nature was extremely sensitive. One who knew him for many years would like to say that he was a true gentleman—one of whom his family, his college, and his university might well be proud.

WILLIAM J. TAYLOR

1861–1936

Dr. William J. Taylor, a member of the American Orthopaedic Association since 1892, died at his home in Philadelphia on January 22, 1936 after a long illness, at the age of seventy-four.

He was graduated from the University of Pennsylvania Medical School in 1882. He very early developed an interest in surgery and was associated with Dr. Weir Mitchell. In 1887, he became assistant to Dr. W. W. Keen who was connected with the Philadelphia Orthopaedic Hospital and Infirmary for Nervous Diseases, and his experiences in this institution led him into the field of orthopaedic surgery. He was Professor of Orthopaedic Surgery in the Philadelphia Polyclinic Hospital from 1893 to 1895. He was also surgeon to the Orthopaedic Hospital for over fifty years and was affiliated with many of the larger hospitals of Philadelphia. He very early identified himself with the College of Physicians of Philadelphia and was its President in 1919, 1920, and 1921, and was most active in promoting the activities of this famous organization. In 1908 and 1909, he was President of the Philadelphia Academy of Surgery and continued a valued and active member of that organization until his death.

During the World War, Dr. Taylor saw active service in France at Base Hospital No. 10, and later as consultant to Medical Headquarters of the American Expeditionary Forces. At the time of his death, he was Lieutenant Colonel in the Reserve Corps.

Dr. Taylor was most highly esteemed by his associates not only because of his surgical ability and judgment but also because of the great friendship and genuine interest which he showed to those with whom he came in contact. Always ready to counsel and aid when occasion offered, he proved himself a real friend and, because of his basic knowledge of surgical principles, enriched by a very large and varied experience, his advice was safe and sane.

He stood for the highest in orthopaedic surgery and was always prepared to give the best in every instance. His pleasant and quiet personality was a marvelous asset in the recovery of his patients. He radiated cheer and confidence to them and thus secured their complete cooperation with his efforts in their behalf.

It does not fall to the lot of many surgeons to earn, win, and hold the esteem, confidence, and love of those with whom they come in contact as did Dr. Taylor. His loss will be felt by patients, friends, and associates, and his wise and stimulating influence and interest in the advance of medical and surgical knowledge will be greatly missed by the many associations and societies (local, national, and international) with which he was connected.

News Notes

The Fiftieth Annual Meeting of the American Orthopaedic Association will be held in Milwaukee, Wisconsin, May 18 to 21, under the presidency of Dr. Frederick J. Gaenslen. Headquarters will be at the Hotel Schroeder. Among the papers to be presented will be the following:

President's Address.
Dr. Frederick J. Gaenslen, Milwaukee, Wisconsin.

History of Fracture Treatment.
Dr. William Arthur Clark, Pasadena, California.

Posterior Dislocation of the Hip with Fracture of the Acetabulum.
Dr. Willis C. Campbell, Memphis, Tennessee.

Reconstruction of Injured Elbows in Children.
Dr. Richard B. Dillehunt, Portland, Oregon.

Fractures and Fracture-Dislocation of the Cervical Spine.
Dr. William G. Turner, Montreal, Quebec.

Treatment of Fractures of the Elbow, Particularly Intercondylar Fractures, by Means of Traction.
Dr. Rudolph S. Reich, Cleveland, Ohio.

The Inclination of the Pelvis and Acetabulum as a Constructive Factor in Slipped Epiphysis and Non-Union in Fractured Hips.
Dr. Lloyd T. Brown, Boston, Massachusetts.

Acute Osteomyelitis: Treatment in the Light of Recent Serological Findings.
Dr. D. E. Robertson, Toronto, Canada.

Septic Hips: A Study of End Results.
Dr. Carl E. Badgley, Ann Arbor, Michigan.

Analysis of Results of Early Treatment of Congenital Dislocation of the Hip by Manipulation and Osteoclasis for Anterior Distortion.
Dr. Arthur Krida, New York, N. Y.
Dr. Paul Colonna, New York, N. Y.
Dr. Francis J. Carr, Jr., New York, N. Y. (By invitation.)

Primary Point of Infection in Tuberculosis of the Hip.
Dr. Dallas B. Phemister, Chicago, Illinois.
Dr. C. Howard Hatcher, Chicago, Illinois. (By invitation.)

Treatment of Bursitis.
Dr. M. N. Smith-Petersen, Boston, Massachusetts.
Dr. Paul Norton, Boston, Massachusetts. (By invitation.)

Bone Metabolism.
Dr. A. Bruce Gill, Philadelphia, Pennsylvania.

Fascial Transplants in Infantile Paralysis and Other Conditions Involving Weakness of the Muscle Groups.
Dr. Frank Dickson, Kansas City, Missouri.

Correction of Paralytic Drop-Foot by Tendon Transplantation.
Dr. Leo Mayer, New York, N. Y.

Treatment of Giant-Cell Bone Tumors.
Dr. Henry W. Meyerding, Rochester, Minnesota.

Arthrotomies for Internal Derangement of the Knee Joint.
Dr. Paul P. Swett, Hartford, Connecticut.

Auscultation of Joints.
Dr. Arthur Steindler, Iowa City, Iowa.

The Inquiry on Articular Pain.
Dr. J. G. Kuhns, Boston, Massachusetts.
Dr. H. L. Weatherford, Boston, Massachusetts. (By invitation.)
Chronic Atrophic Arthritis.
Dr. Theodore A. Willis, Cleveland, Ohio.
Series of Fractures of Neck of the Femur United with Excellent Functional Results after Treatment by Means of Smith-Petersen Nail.
Dr. Lawson Thornton, Atlanta, Georgia.
Dr. Calvin Sandison, Atlanta, Georgia. (By invitation.)
The Wave Mechanics of Muscle Motion.
Dr. Eben J. Carey, Milwaukee, Wisconsin. (By invitation.)
Factors Influencing the Balance of the Foot in Walking.
Dr. R. Plato Schwartz, Rochester, New York.
The Occurrence of Abscesses from Hips That Are Firmly Ankylosed. Dr. Z. B. Adams, Boston, Massachusetts.

The next Congress of the **International Society of Orthopaedic Surgery** is to be held in Bologna, Italy, from September 21 through September 25, 1936, under the presidency of Prof. Dr. Vittorio Putti. The meeting will be opened by a General Assembly on the afternoon of the first day, followed in the evening by the President's Dinner. The next three days will be devoted to the presentation and discussion of papers. On the afternoon of the fourth day, the members will leave for Rome where, on the closing day, they will have an opportunity to visit the new Clinic of Orthopaedic Surgery and to observe various clinical demonstrations.

The Sixth **Sir Robert Jones Lecture** was presented on February 6, 1936 at the Hospital for Joint Diseases, New York City, by Dr. Frederick J. Gaenslen. His subject was "Fracture of the Neck of the Femur".

The next Congress of the **Deutsche Orthopädische Gesellschaft** will be held in Königsberg Pr. on August 28, 29, and 30, 1936, under the presidency of Prof. Dr. Lothar Kreuz. The principal subjects to be discussed are: "The Knowledge and Treatment of Talipes Calcaneus", "The Biology of Amputations", and "Pathological and Clinical Considerations of Acute Lumbago".

The Congress of the **Czechoslovakian Orthopaedic Society** is to be held in Bratislava on June 27, 28, and 29, under the presidency of Prof. Dr. Mikula. The principle subject of discussion will be "Inflammation of the Joints". Prof. Frejka will present a paper on the subject of "Conservative Treatment for Inflammation of the Joints". Prof. Mikula will speak on "Arthroplasties" and Prof. Zahradníček will talk on "Treatment of Fractures of the Neck of the Femur".

The fourth meeting of **La Réunion d'Orthopédie et de Chirurgie de l'Appareil Moteur de Bordeaux** was held in Bordeaux on November 28, 1935. In opening the meeting, the President paid a tribute to the memory of Dr. Gourdon, calling attention to his efforts in promoting orthopaedic surgery and his remarkable contribution since the War to the rehabilitation of the maimed. He was also one of the founders of the Society. Sixteen communications on interesting subjects were presented by different members and guests. These papers will be found printed in full in the *Journal de Médecine de Bordeaux et du Sud-Ouest*, the issue of January 20, 1936.

The second examination given by the **American Board of Orthopaedic Surgery** was held in St. Louis on January 11, 1936. Eighty-four candidates were certified at this time. Approximately 10 per cent. of the candidates failed to meet the requirements of the Board at this examination. The next examination will be held in conjunction with the annual meeting of the American Medical Association, to be held in Kansas City on May 11, 1936. Further information may be obtained from Dr. Fremont A. Chandler, Secretary, 180 North Michigan Avenue, Chicago, Illinois.

The next meeting of the **International Society for Crippled Children, Inc.** is to be held in Budapest from June 29 to July 3, 1936, under the patronage of the Government of Hungary and the Municipality of Budapest. The meeting is to be held under the auspices of the International Society for Crippled Children and the Hungarian Society for the Crippled, and the chairman will be Prof. Dr. Michael Horvath, of the University of Budapest. There will be an informal social gathering on Sunday, June 28. On Monday evening, June 29, a reception will be given by the Hungarian Government and on Tuesday evening, June 30, there will be a reception by the Municipality of Budapest. An interesting program for this session has been arranged. Further information may be obtained from Mr. Paul King, President, 1066 Federal Building, Detroit, Michigan.

The slogan of the **National Tuberculosis Association** for 1935, "Fight Tuberculosis with Modern Weapons", was so effective that by unanimous consent it is to be repeated for the Early Diagnosis Campaign of 1936. Emphasis is placed on the value of the early discovery of tuberculosis and the necessity of the patient's seeking medical advice promptly. The wisdom of anticipating the onset of tuberculosis by pushing the fight nearer to its source is also stressed. Pamphlets and posters are available for giving wide publicity to this subject. The Association has continually endeavored to bring important information on this subject before the public, and has been largely instrumental in bringing about the marked diminution of the disease throughout the country.

Lord Nuffield, who has always been interested in the problem of the care of the crippled, has already contributed very generously to provide for the hospital equipment and treatment of these individuals in England, New Zealand, and Australia, with the special object of discovering and treating children attacked by some crippling disability. For a long time, Lord Nuffield has been anxious to help forward this work in Great Britain, in order that in every area suitable provision may be made for the early and adequate treatment of every child, adolescent, and adult in need of it. He has now presented the sum of 125,000 pounds to provide for the early and efficient orthopaedic treatment of cripples. The major portion of this sum will be allocated to a Lord Nuffield Central Fund which is to be applied at the discretion of the trustees during the next four or five years toward developing this project. Another part of this amount is to be devoted to the endowment of a Scholarship in Orthopaedic Surgery, to be tenable for two years at the Wingfield-Morris Orthopaedic Hospital, with a travel period of three months to follow. This most generous provision of Lord Nuffield's, which allows study in a well-organized orthopaedic hospital of the most modern design, should be attractive and of value to young surgeons who are to specialize in orthopaedic surgery.

The Fourth Annual Convention of the American Academy of Orthopaedic Surgeons was held in St. Louis, Missouri, on January 13, 14, 15, and 16, 1936, under the presidency of Dr. Frank D. Dickson.

Three morning and afternoon sessions were devoted to the presentation of scientific papers, including a symposium on "Bone Tumors" and another on "Fractures in and around the Elbow Joint". Orthopaedic clinics were held at five St. Louis hospitals on the morning of January 16.

There were thirty-two scientific exhibits and thirty-eight technical exhibits. Prizes for scientific exhibits were awarded by a committee consisting of Dr. Ludvig Hektoen, Chairman, Dr. Arthur Steindler, and Dr. Robert Terry. The Gold Medal was awarded to Dr. Henry Kessler, Newark, New Jersey, for his exhibit on "Cineplastic Amputation". The Silver Medal was awarded to Dr. Sherwood Moore, St. Louis, Missouri, for his exhibit on "Leontiasis Ossea Familiale Juvenile". The Bronze Medal was presented to Dr. Eugene W. Wolcott, Des Moines, Iowa, for his exhibit on "A Study of the Circulation in the Head and Neck of the Femur as Supplied through the Ligamentum Teres and Capsular Vessels". Certificates of Honorable Mention were awarded to Dr. Ralph K. Ghormley and Dr. A. E. Deacon, Rochester, Minnesota; Dr. G. Edmund Haggart, Boston, Massachusetts; Dr. John P. Lord, Dr. Robert D. Schrock, and Dr. Herman F. Johnson, Omaha, Nebraska; Dr. Leo Mayer, New York, N. Y.; Dr. Joseph E. Milgram, New York, N. Y.; and Dr. Austin T. Moore, Columbia, South Carolina.

The six radio talks given under the auspices of the Academy were as follows:

Physically Handicapped Children and Adults.
Dr. J. Archer O'Reilly, St. Louis, Missouri.

Progress in American Orthopaedic Surgery.
Dr. Melvin S. Henderson, Rochester, Minnesota.

Infantile Paralysis.
Dr. Philip Lewin, Chicago, Illinois.

Modern Treatment of Bone and Joint Injuries.
Dr. Frank D. Dickson, Kansas City, Missouri.

Bone Tumors.
Dr. Henry W. Meyerding, Rochester, Minnesota.

Fractures.
Dr. J. Albert Key, St. Louis, Missouri.

The Academy voted to hold its next Annual Meeting in Cleveland, Ohio, on January 11, 12, and 13, 1937.

The following officers were elected for 1936:

President: Dr. Melvin S. Henderson, Rochester, Minnesota.
President-Elect: Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
Vice-President: Dr. W. B. Carrell, Dallas, Texas.
Treasurer: Dr. E. Bishop Mumford, Indianapolis, Indiana.
Secretary: Dr. Philip Lewin, Chicago, Illinois.

BRITISH ORTHOPAEDIC ASSOCIATION

The British Orthopaedic Association held its Annual Meeting in Manchester on October 25 and 26, under the Presidency of Mr. Harry Platt.

The opening morning was devoted to a discussion on three aspects of:

FRACTURES OF THE OS CALCIS:

I. *Economic Results*

A discussion of the subject was led by Mr. B. L. McFarland and Mr. W. J. Eastwood, of Liverpool, who were followed by Mr. J. P. Hosford, Mr. R. J. Furlong, and Mr. T. T. Stamm, all of London. The speakers were agreed that the final result depended on whether or not the subastragaloid joint was disorganized. If it was not involved, an excellent functional result ensued in the majority of patients. Where the joint surfaces were disturbed, permanent disability was liable to follow for two reasons: (1) the development of a painful arthritis; and (2) the weakness of the calf muscles consequent upon upward displacement of the posterior fragment of the os calcis. Experience had not shown that the type of treatment employed appeared to influence materially the ultimate function of the foot. Restoration as far as possible of the normal anatomy of the os calcis by the powerful skeletal-traction method advocated by Böhler of Vienna in the few cases

so treated had not permitted the patient to resume heavy labor any more successfully than had simple manual molding and fixation in plaster-of-Paris for several months. Nor had this method shortened the time in which the individual could return to lighter occupations.

II. *Results of Attempted Reduction in a Series of Recent Fractures*

By invitation of the Association, Dr. E. E. Myers, of Boston, Massachusetts, reviewed a series of thirty-three consecutive fractures involving the subastragaloid joint which had been treated in the Fracture Services of the Ancoats Hospital and the Manchester Royal Infirmary. These were divided into two groups. The first group comprised eighteen fractures in which an attempt had been made, with varying success, to restore the normal anatomy of the os calcis by powerful skeletal traction and compression. More than half of this group of patients were able to return to their original arduous duties without subjective symptoms and with no appreciable impairment of the function of the foot. The second group consisted of fifteen fractures treated only by manual manipulation and fixation in plaster-of-Paris. Of this group, only one-third of the patients were able to return to heavy work.

Dr. Myers emphasized two facts: (1) that the results were invariably better in the light, wiry type of individual; and (2) that in those patients in whom the best results had been achieved the subastragaloid joint was clinically ankylosed.

He concluded that a very definite advance in the treatment of these fractures had been made by attempts to restore the normal anatomy of the foot, and suggested that in certain cases, following a reduction, early arthrodesis of the subastragaloid joint might be expected to increase further the numbers of good functional results.

III. *The Treatment of Old Fractures*

Mr. R. Ollerenshaw, of Manchester, said that, if a two-year period was allowed to elapse before a final analysis of these fractures was made, the general results were not so disheartening. In reviewing a series of forty-five patients, in all of whom the fractures were more than three years old, he had found that thirty-four had returned to their original work. For those who continued to complain of pain, his routine was the manipulation of the foot into inversion and the application of a plaster-of-Paris cast for several weeks. A very small number of old fractures required a subastragaloid arthrodesis, but this procedure could not always be relied upon to produce complete relief of symptoms.

On the second morning several short papers were read, as follows:

Use of the Sub-Standard Kinematograph Films in Case-Recording
by Mr. R. Ollerenshaw, Manchester

The Mechanism of Bone Absorption
- Histological Aspects — by Prof. S. L. Baker, Manchester
- Roentgenological Aspects — by Dr. E. W. Twining, Manchester (by invitation)

Congenital Torticollis — by Mr. C. H. Gray, Manchester

Osteochondritis in Congenital Dislocation of the Hip
by Dr. M. F. Johnstone, Manchester

Fractures of the Internal Epicondyle of the Humerus
by Mr. H. O. Clarke, Manchester

The following officers were elected for the year 1936:

President: Mr. W. R. Bristow
Vice-President: Mr. T. P. McMurray
Treasurer: Mr. S. L. Higgs
Secretary: Mr. E. P. Brockman
Editorial Secretary: Mr. H. O. Clarke
Executive Committee: Mr. R. Ollerenshaw
Mr. A. Rocyn-Jones

At recent meetings of the Executive Committee of the **British Orthopaedic Association,** the following were elected to membership:

Honorary Members

Dr. J. Delchef, 34 Rue Montoyer, Brussels, Belgium
Prof. A. Maffei, 42 Rue de Livourne, Brussels, Belgium

Full Members

Mr. R. W. Butler, Grove Lodge, Cambridge
Mr. W. J. Eastwood, 69 Rodney Street, Liverpool

Associate Members

Mr. W. V. Anderson, Fraser House, Colinton, Midlothian, Scotland
Mr. William Barclay, 5 Murray Road, Huddersfield
Mr. W. Sayle Creer, The Craige, West Lane, Freshfield, Liverpool
Mr. James Dawson, The Nook, Keighley Road, Bradford, Yorks.
Mr. E. Bell Jones, 6 Gambier Terrace, Liverpool
Mr. R. J. Katrak, New Sitaran Building, Princess Street, Bombay, India
Mr. A. M. A. Moore, 89 Harley Street, London, W. 1
Mr. S. B. Morris, 7 Waiata Avenue, Remuera, Auckland, S. E. 2, New Zealand
Mr. R. P. Osborne, Park Hospital, Davyhulme, Manchester
Mr. T. B. Reid, Park View, Grove Hill, Middlesborough
Mr. David Trevor, 18 Devonshire Street, Portland Place, London, W. 1
Mr. W. E. Tucker, 62 Wimpole Street, London, W. 1
Mr. D. Wainwright, Mill Road Infirmary, Liverpool

The Spring Meeting of the **British Orthopaedic Association** is to be held in Brussels, April 22 to 26, 1936, with headquarters at the Palace Hotel.

Current Literature

Diagnostic Roentgenology. Ross Golden, M.D., Editor. New York, Thomas Nelson and Sons, 1936. $20.00.

With the advent of the roentgen ray and the vast amount of knowledge which has resulted from each of the new methods of investigation, there has also come to the physicians employing these methods an increased responsibility in fitting themselves to use this information more accurately. In no branch of medicine in which investigations have been made and laboratory methods have been developed is it more important than in the field of roentgenology. Dr. Golden has emphasized the necessity of a broad foundation of medical education, training, and experience for those who occupy themselves especially with the interpretation of evidence as given by the roentgenogram. He calls attention to the error of using roentgenographic reports as a short cut in diagnosis rather than as corroborative evidence of clinical findings.

Dr. Golden has presented in this large book of 854 pages a most complete work on the subject of diagnostic roentgenology. He has divided the book into eleven chapters with the following subjects, which indicate the extensive scope of this volume:

The Roentgen-Ray Diagnosis of Diseases of the Skull and Intracranial Contents;
The Roentgen-Ray Examination of the Paranasal Sinuses and the Mastoids;
Radiology of the Chest;
Clinical Roentgenology of the Cardiovascular System;
The Roentgen-Ray Examination of the Digestive Tract;
The Roentgen-Ray Diagnosis of Diseases of Bones;
The Roentgen-Ray Diagnosis of Spinal Cord Tumors;
Roentgenologic Diagnosis of Diseases of the Urinary Tract;
Uterotubography;
The Use of the Roentgen Ray in Obstetrics;
The Radiology of Fractures.

In the preparation of this work, Dr. Golden has been aided by the following collaborators whose experience has particularly fitted them to speak with authority on this subject: Alexander Brunschwig, Cornelius G. Dyke, George W. Grier, Paul C. Hodges, Leopold Jaches, Howard C. Moloy, Dallas B. Phemister, Coleman B. Rabin, Samuel A. Robins, Hugo Roesler, Albert A. Shapira, Edward H. Skinner, Marcy L. Sussman, and Paul C. Swenson.

The scope of this book covers the use of roentgenology in practically all parts of the body. Each subject is described in detail and is fully illustrated by excellent photographs, roentgenograms, drawings, and charts. The plan has been followed of giving a descriptive clinical review of each subject, including the etiology, pathology, and in many cases the treatment. So frequently the information given by the roentgenogram is of such material aid in determining the course to be followed in the treatment of these cases that it is decidedly helpful to have a discussion of this relationship. These descriptions are excellent and help the reader to understand the interpretation of the roentgenograms.

The plan of supplementing the roentgenographic findings and illustrations with a complete explanation of the conditions which they illustrate, as well as the comprehensive scope, allows the volume to be used more for general reference than simply as a text-book on roentgenology. The book is published in an extensible form, so that other portions may be added at any time.

This volume will be found valuable by every practitioner of medicine and every surgeon.

THE PARATHYROIDS IN HEALTH AND IN DISEASE. By David H. Shelling, B.Sc., M.D. St. Louis, The C. V. Mosby Co., 1935. $5.00.

This monograph, written by a physician who is also a scientist, constitutes the finest and most comprehensive review of the normal and pathological physiology of the parathyroid glands that is to be found in the literature today. As has been stated in the preface, "The physiologists have concerned themselves with the problem of parathyroid extirpation and its effects on the nervous system; the chemists have studied the chemical changes in the blood and excreta which result from dysfunction of these minute bodies; the pathologists have investigated the changes which occur in the parathyroids in systemic diseases, as well as the changes which dysfunction of the parathyroids may produce in the other tissues of the body; and, last, the clinicians have contributed to the symptomatology of disease associated with parathyroid derangements. The scattered information from these various sources has rarely been molded together into an homogeneous whole. The several excellent periodic reviews on the parathyroids, such as those of J. B. Collip in *Physiological Reviews*, W. G. MacCallum in *Medicine*, and G. Hersheimer in Henke-Lubarsch's *Handbuch der speziellen pathologischen Anatomie*, have dealt, for the most part, either with physiology or with pathology, rather than with the subject as a whole. The less recent reviews have become obsolete, owing to the rapid progress which has been made in the past decade, especially in the chemical and clinical phases of the subject."

Dr. Shelling has succeeded in bringing up to date, in a concise form and with a style that is interesting and easy to follow, the knowledge that has been compiled by hundreds of physiologists and clinicians. He has further succeeded in tying together the great heterogeneous mass of published theories and facts into a composite statement.

The question which is often asked, "What is the present status of the parathyroid glands and their importance in clinical medicine?", can best be answered by referring those interested to this book. More than half of the book deals with the anatomy and physiology of the parathyroid glands with particular reference to hypoparathyroidism. The newer subject of hyperparathyroidism and osteitis fibrosa is adequately covered. There are sections in which the author expresses his opinions, as well as those of other workers, concerning the relation of the parathyroid glands to the other glands of internal secretion and to vitamin D.

This reviewer most enthusiastically recommends this monograph on the parathyroid glands to the physiologist, the pathologist, the chemist, the internist, the roentgenologist, and the surgeon. No student of endocrinology can afford to be without it.

THE RADIOLOGY OF BONES AND JOINTS. By James F. Brailsford, M.D., M.R.C.S. Ed. 2. Baltimore, William Wood & Co., 1935. $9.00.

Although only a year has elapsed since the appearance of the first edition of this book, so much progress has been made in many of the departments of radiology that the author has been able to supplement the material in the first edition by discussing many of the results of these researches of the past year. This second edition is dedicated to the memory of Sir Robert Jones.

The chapters on "Osteochondritis", "Bone Dystrophies", and "Spondylolisthesis" have been rewritten and a chapter on "Dental Radiography" has been added. The index has also been revised to enable the reader to find more readily the material desired.

In the second edition, the general plan of arrangement found in the first volume has been followed, — the descriptions of the roentgenographic appearance of the various conditions are accompanied by descriptions of the diseases and malformations which are illustrated by the roentgenograms. In the new chapters, the subjects are considered in a particularly comprehensive way; not only is there a complete description of the findings, but the conditions which are illustrated are discussed with relation to their etiology, pathology, and treatment. The book is wide in scope and is profusely illustrated by very excellent roentgenograms, and in many cases tracings from roentgenograms have been added to illustrate more clearly the conditions described.

The plan of including a discussion of the present status of many of the subjects which are illustrated, which is now being followed by many writers on this subject, contributes very largely to the value of a work of this kind; and this added information stimulates the constantly increasing interest in the study of radiology.

Dr. Brailsford is constantly augmenting our fund of knowledge on this subject and the present volume bears witness to his experience and painstaking study.

THE DIAGNOSIS AND TREATMENT OF DISEASES OF THE PERIPHERAL ARTERIES. By Saul S. Samuels, M.D. New York, Oxford University Press, 1936. $3.50.

This volume of 350 pages is a simple, concise presentation of the modern methods for the diagnosis and treatment of peripheral-arterial diseases. It is based on the long experience of the author, who reports 350 cases of thrombo-angiitis obliterans with only one amputation. Each chapter is followed by a complete bibliography. New procedures and unproved opinions are given only a brief discussion; most of the treatise is reserved for the problems of the two major organic diseases.

The volume will be appreciated by those especially interested in arterial diseases because it includes the summation of a large series of cases successfully treated, with an orderly reference to the literature. It will be of far greater value, however, to the general practitioner, who will find the book so well written and explicit that he will gain such information as will enable him to recognize early cases of thrombo-angiitis obliterans and arteriosclerosis without the aid of special equipment. Apparently, the object of the author is to clarify the conception generally held by the profession and to present rational procedures of diagnosis and treatment on simple, conservative, and efficient lines.

Two full chapters are given to a general discussion of the subjective and objective symptoms of diminished peripheral circulation. One chapter is devoted to oscillometry.

Next, is the usual sequence discussion of thrombo-angiitis, followed by case reports. Much detail is given to diagnosis and treatment.

The other major organic obtructive disease, arteriosclerosis obliterans, is presented in the same manner.

The groups of conditions, such as Raynaud's disease, resulting from vasomotor imbalance are given less discussion in accordance with their clinical importance.

Some readers will not agree with the author's conclusions in every instance, but, for clearness in stating the essential facts and for application in the field of general practice, this volume is a valuable addition to medical literature.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Anales (Valencia), II, Núms. 19–24, 1935.
Anales de Cirugía (Rosario), I, No. 2, 1935.
Anales de Pediatría (Facultad de Medicina de Barcelona), II, Núm. 20, 1935.
Boletim da Secretaria Geral de Saúde e Assistencia (Rio de Janeiro), I, No. 3, 1935.
Boletines de la Sociedad de Cirugía de Rosario, II, Núms. 1–7, 1935.
Bulletin of the National Tuberculosis Association, XXIII, Nos. 1 and 3, 1936.
Children's Hospital of Winnipeg. Twenty-Seventh Annual Report. 1935.
Cleveland Clinic Quarterly, III, No. 1, 1936.
Journal of the Indian Medical Association (Calcutta), IV, Nos. 12 and 13, 1935; V, No. 3, 1935; V, No. 4, 1936.
Journal of South Indian Medicine (Madras), II, Nos. 3 and 4, 1935.
L'Action Médicale (Montréal), XI, No. 12, 1935.
Revista de Medicina (Buenos Aires), I, Núm. 2, 1935.
Roentgen Economist, IV, No. 2, 1936.
Wiener medizinische Fakultät. Programm des 57. Fortbildungskursus: Internationalen Fortbildungskursus über Fortschritte der Therapie bei inneren Krankheiten mit besonderer Berücksichtigung der Nachbargebiete. 1936.

EINE RÖNTGENOLOGISCHE STUDIE ÜBER ARTHRITIS ACROMIALIS (An X-Ray Study of Acromioclavicular Arthritis). K. Lindblom. *Acta Chirurg. Scandinavica*, LXXVII 174, 1935.

A review of the roentgenograms in two views of 419 acromioclavicular joints establishes the fact that hypertrophic arthritis of the acromioclavicular joint can be shown roentgenographically in many cases of shoulder pain. This arthritis is often the explanation of the shoulder pain. A single severe trauma is probably the most frequent cause of the arthritis.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

ON THE TREATMENT OF TUBERCULOSIS OF THE TALOCRURAL AND TALOCALCANEAL JOINTS. Robert Hanson. *Acta Orthop. Scandinavica*, VI, 19, 1936.

There were 110 cases of tuberculosis of the foot and ankle in 3,055 cases of surgical tuberculosis. The ankle joint alone was involved in fifty-three, the ankle and talocalcaneal joints in twenty-nine, the ankle, talocalcaneal, and talonavicular joints in sixteen, the talocalcaneal joint alone in eleven, and the talocalcaneal and talonavicular joints in one. Age and sex are tabulated and eleven illustrative cases are summarized.

Involvement of the posterior talocalcaneal joint is often secondary to that of the ankle joint, but may result from primary involvement of either the talus or calcaneum. The anterior talocalcaneal joint was spared in thirty-six cases of involvement of the posterior talocalcaneal joint, apparently because of the separation of the joints by the interosseus ligament.

Resection was performed in twenty-seven cases of tuberculosis of the ankle joint and is recommended rather than astragalectomy in adults. Astragalectomy is better in children. Conservative treatment was employed in thirty-six cases and has been successful, temporarily at least, in four.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

ZUR KENNTNIS DER SKELETTVERÄNDERUNGEN BEI DER SCHÜLLER-CHRISTIAN'SCHEN KRANKHEIT. (XANTHOMATÖSE SPONDYLOSE MIT PARAVERTEBRALER SCHATTENBILDUNG.) Skeletal Changes in Schüller-Christian Disease. (Xanthomatous Spondylosis with Paravertebral-Shadow Formation.) Gösta Jansson. *Acta Radiol.*, XVI, 59, 1935.

The author describes a case of Schüller-Christian disease which, besides the characteristic defects of the cranial and thigh bones, showed destruction of a thoracic vertebra. The xanthomatous spondylosis was accompanied by a paravertebral-shadow formation exactly resembling the gravitation abscesses occurring in tuberculous spondylitis. The production, in connection with xanthomatous spondylosis, of a roentgen shadow resembling that of a gravitation abscess is something which has never been observed before. In the author's opinion, it is due to a paravertebral accumulation of lipoid granulation masses.—*Lewis Cozen, M.D., Iowa City, Iowa.*

THE MALIGNANT TUMORS OF THE PERIPHERAL NERVES. Arthur P. Stout. *Am. J. Cancer*, XXV, 1, Sept. 1935.

This paper reports a careful study of the malignant tumors of the peripheral nerves. It contains an excellent bibliography and is fully illustrated with photomicrographs and photographs of gross specimens. The author reviews the literature and adds new cases from his experience. He goes thoroughly into the classification of the tumors and the clinical characteristics of the various types. He recognizes two groups of malignant tumors,—those which have the morphological characteristics of malignant fibroblastic tumors and those which are epithelial in type and reproduce in a recognizable form neuro-ectodermal structures. The majority of the former tumors occur in individuals suffering with von Recklinghausen's disease. The neuro-epithelial group of tumors is very rare and presents diverse histological features.

It is very interesting that these tumors present so little interference with motor nerves and that they so seldom need to be considered in the differential diagnosis of orthopaedic problems.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Tumors of the Peripheral Nerves. Charles F. Geschickter. *Am. J. Cancer*, XXV, 377, Oct. 1935.

This paper is based on the material available for study at the Johns Hopkins Hospital laboratories and includes the benign as well as the malignant tumors of the peripheral nerves.

The impressive characteristic of these tumors is that they have such a very minor orthopaedic significance. Tumors of the cauda equina may give rise to pain strongly suggestive of sacro-iliac disease and are frequently accompanied by flaccid paralysis, with loss of reflexes. In general, however, the tumor is the presenting characteristic in these cases and impairment of motor function or pain suggestive of bone or joint disease is exceptional. A brief section deals with amputation neuromata without bringing out any new features. Individuals wishing to pursue study in these fields would do well to consult the original paper which is excellently organized and annotated.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Chordoma: A Study of 150 Cases. Roy E. Mabrey. *Am. J. Cancer*, XXV, 501, 1935.

This article reviews from a clinical standpoint all cases of chordoma reported to date and adds eight additional cases, bringing the total to 150. Chordoma is a rare and usually fatal tumor which arises from the foetal notochord, and the majority of the tumors appear in the sacrococcygeal region. The cranial chordoma is next most common, and there are also some rare instances of vertebral chordoma. The greater incidence in males raises the question of the etiological significance of trauma.

Pain is the most common symptom in all of these cases and tumor is the next most common observation. Rectal symptoms are fairly common in cases where the tumor is located in the sacrococcygeal region. Paralysis or weakness of the arms or legs may occur, especially in connection with the cases involving the vertebrae. Since the tumor arises in the nucleus pulposus, fracture of the vertebra and rupture of the intervertebral disc have to be considered in the differential diagnosis.

The benign giant-cell tumor, tuberculosis, osteoma, chondroma, and chrondrosarcoma also must be considered at times in the differential diagnosis. Roentgenographic examination usually shows a soft-tissue shadow with destruction of the bone. The lesion is not a bone tumor and proliferation is not to be expected. The presence of a painful swelling of long duration in the sacral region, coupled with an irregular defect in the sacrum, demonstrable by the roentgenogram, is suggestive of chordoma. A photomicrograph shows the characteristic large epithelial-like vacuolated cells which confirm the diagnosis.

Treatment is unsatisfactory from the standpoint of cure. In cases of vertebral chordoma, laminectomy may be desirable to relieve cord pressure. The tumors are very vascular and surgical removal is often hazardous. Radiation is not particularly effective in controlling the growth, although it sometimes relieves pain.

Metastases, involving chiefly the regional lymph nodes, liver, or lungs, have been found in a rather high percentage of reported autopsies.

The paper is well illustrated with roentgenograms, photomicrographs, and photographs of gross specimens. It presents numerous tables dealing with the distribution, age incidence, duration of symptoms, etc. There is a good bibliography of the recent literature.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Bone Metastasis in Carcinoma of the Stomach. H. Dabney Kerr and Raymond A. Berger. *Am. J. Cancer*, XXV, 518, 1935.

The authors point out that bone metastasis from carcinoma of the stomach is relatively infrequent. The total number of cases showing bone involvement is usually assumed to be less than 6 per cent. In a review of 143 apparently authentic cases in the literature, to which they added five more from their own experience, the authors found

that the commonest sites of bone metastasis from carcinoma of the stomach appear to be in the spine, ribs, femur, sternum, and pelvis. Osteoblastic metastases are about as common as the purely destructive lesions. Bone metastases appear to be more frequent in relatively young patients. Some of the patients show an anaemia which cannot be distinguished morphologically from a primary type and which may show a large percentage increase of immature cells of the myeloid series.

The paper presents roentgenograms and photomicrographs and includes a very careful bibliography.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Artificial Fever Therapy of Gonorrheal Arthritis. Report of Thirty-One Cases. H. Worley Kendall, Walter W. Webb, and Walter M. Simpson. *Am. J. Surg.*, XXIX, 428, 1935.

During the past three years, the outlook for patients with gonorrhoeal arthritis has been enormously improved. This report is based on thirty-one cases in which several forms of treatment were used, including hot baths, cabinets with carbon-filament electric bulbs, electric blankets, diathermy, and radiothermy. The clinical results were essentially similar when the fever could be maintained over a sufficiently long interval. The apparatus used for fever induction and maintenance was for the most part the air-conditioned "Kettering hypertherm". The average set of air conditions to which the patient's body is subjected are: dry-bulb air temperature of 140 to 150 degrees Fahrenheit; relative humidity of 35 to 40 per cent., and air velocity of 425 cubic feet per minute. The elevation of rectal temperature to 105 degrees is usually obtained in forty minutes. During the treatment, two to four liters of sodium chloride solution (0.6 per cent.) is given by mouth to replace the chloride loss.

The *in vitro* thermal death point of fifteen strains of gonococci was determined at different temperature levels. At 102 degrees Fahrenheit, growth was not appreciably affected. At 104 degrees, about 99 per cent. of the organisms were killed by ten hours' exposure. At 105.8 degrees, 99 per cent. were killed by from four to five hours' exposure; the remaining 1 per cent. required from eleven to twenty-three hours. At 106 degrees, 99 per cent. were rendered non-viable in two hours, while the remaining 1 per cent. required five to twenty hours.

During the past four years, the authors have treated 383 patients and have given 2,844 fever treatments without injury to any person. Patients are given four to five treatments of five to seven hours' duration with a therapeutic range of 106 to 106.8 degrees Fahrenheit at intervals of three to five days. In 74 per cent. of the author's cases, the disease was polyarticular. Twenty-three patients had positive smears. Of the eight patients with negative smears, three had acute gonorrhoeal arthritis and five had chronic arthritis. Following the course of treatment, twenty-four patients showed a negative smear. The smears of seven patients were still positive, but in four of these cases the smears became negative in two weeks.

Of the nineteen patients with acute gonorrhoeal arthritis, the average improvement in joint function immediately following the fever treatment was 27.5 per cent.; in three patients, the joint restoration was complete. Of the twelve patients with chronic gonorrhoeal arthritis, the average improvement at the conclusion of the course was 62.5 per cent. In four cases, joint function was completely restored. At the present time, the average improvement in joint function in the acute cases is 98.5 per cent.; in the chronic cases, 88.3 per cent.—*Paul Siman, M.D., Iowa City, Iowa.*

Tuberculosis of the Shafts of Long Bones; Clinical and Roentgenological Study with a Report of Eight Cases. C. K. Petter and J. P. Medelman. *Am. Rev. Tuberc.*, XXXII, 285, 1935.

Of 4,896 patients admitted to Glen Lake Sanatorium, 275 had bone and joint tuberculosis, with or without pulmonary manifestations. Of this latter number, eight patients had tuberculosis of the shafts of the long bones. This type of lesion, therefore, is ex-

tremely rare. The authors believe that tuberculosis of the shafts of long bones is primarily destructive in the cancellous portion, becoming proliferative when the periosteum is approached. In the differential diagnosis of lesions in the shafts of long bones, tuberculosis, syphilis, and pyogenic osteomyelitis should always be considered.—*Clarence A. Ryan, M.D., C.M., Vancouver, B. C., Canada.*

Zur Behandlung der Osteomyelitis im Kindesalter (Treatment of Osteomyelitis in Childhood). Max Langer. *Arch. f. klin. Chir.*, CLXXXI, 640, 1935.

Langer is very careful and conservative in the treatment of osteomyelitis. If nothing is found on the bone, only the soft tissues are incised. If the soft-tissue abscess is surrounded by a thick muscle mass, a rubber drain is inserted for from one to two days to prevent full closure. Otherwise, the skin edges are approximated by stitches placed at wide distances from each other. If the infected bone lies superficially, small incisions, one-half of a centimeter in length, are sufficient without the insertion of a drain. If the focus is close to the shoulder or hip joint, an extension bandage is applied. If other areas are involved, the neighboring joints are immobilized by plaster splints. Langer never uses circular plaster bandages. If sequestra have formed, they are surgically removed only if they present themselves in the sinus tract. The elimination is left almost entirely to nature. This method of treatment has been used by the author for the last four years and he states that during that time chronic osteomyelitis, with all its sequelae, has become a rare disease in his hospital.

During these four years, forty-two patients with osteomyelitis were admitted to the hospital; seven of these patients died in the first week. In twenty-two cases, all of the sinuses healed within two years. The roentgenograms did not reveal signs of activity. Thirteen patients did not return to the hospital.—*Ernst Freund, M.D., Venice, Florida.*

Röntgendiagnostik der Erkrankungen in der Zwischenwirbelscheiben (Roentgenographic Diagnosis of Diseases of the Intervertebral Discs). N. A. Podkaminsky. *Arch. f. klin. Chir.*, CLXXXII, 352, 1935.

The author reviews the different pathological changes in the intervertebral discs with anatomical and roentgenographic manifestations and discusses them under five headings.

1. Pathology of the cartilaginous plate of the intervertebral disc. The cartilaginous plate between disc and vertebral body is of great importance under normal conditions in the growth of bone; under pathological conditions, it becomes of even greater significance. The author mentions especially the herniation through the cartilaginous plate into the vertebral body, the so called Schmorl nodules. They are frequent, being found in 38 per cent. of all cases examined. They can be demonstrated *in vivo* by x-ray only if a zone of reactive osteosclerosis has formed around the body. Of interest is the differential diagnosis between congenital and traumatic joint bodies. The presence of other traumatic lesions (fractures of apophyses, ruptures, ligaments, etc.) and the localization of the lesion may be of help. If cartilaginous bodies are found in the cervical spine, they are usually due to trauma. If there is good function of the spine, the presence of cartilaginous bodies does not indicate disability.

2. Diseases of the annulus lamellosus. The intervertebral disc proper has vessels up to the end of the growth period. This shows that a number of infectious diseases (sepsis, grippe, typhus, tuberculosis, etc.) may affect the disc through the blood stream. After the age of twenty-five, most of the changes in the intervertebral disc are due to degeneration resulting from insufficient nutrition by diffusion. The degeneration of the disc may be followed by secondary vascularization with fibrosis. Podkaminsky thinks that he can demonstrate degeneration and fibrosis of the intervertebral disc in the roentgenogram. The lateral portion shows, on one side or both sides, a homogeneous dark

shadow without any signs of spondylarthritis. These changes can apparently be demonstrated only in the lumbar spine. In such cases of fibrosis of the intervetebral disc, the lumbar spine shows stiffness, and low-back pain is present. In older patients, this x-ray symptom is due to the wear and tear on the tissue. In some cases, the fibrosis of the disc may be only the first sign of an ossifying process which leads to "discosis spongiosa", as the author calls it. In such cases, the roentgenogram shows at the site of the intervertebral space spongy bone without alteration of the vertebral bodies. As far as the calcification of the intervertebral disc is concerned, Podkaminsky does not agree with Bársony and Koppenski, who differentiated two types of calcification: a central one in the nucleus pulposus and a peripheral one in the fibrous annulus. He thinks that the differentiation is too schematic. He believes that calcification, discosis petrificans, may occur wherever there is degeneration. Inflammatory processes, disturbed calcium metabolism, and trauma are predisposing factors. In cases in which degeneration is combined with considerable destruction, compression of the disc takes place (discosis atrophicans or discitis destructiva). Narrowing of the intervertebral space is the roentgenographic sign. The converse, increased intervertebral space (discosis hypertrophicans), is present in cases of osteoporosis.

3. Diseases of the nucleus pulposus. The nucleus pulposus is usually the first site of degeneration and Podkaminsky advances the following theory of spondylarthritis deformans. Due to a disturbance in the function of the synovial enzymes present in the nucleus pulposus, colloids become precipitated. The lymph sinuses become more or less extensively occluded; the nutrition of the fibrous ring is impaired, causing its degeneration and loss of elasticity. The changes in the bone are secondary and reactive.

4. Paradiscosis. Besides homogeneous ossification of the intervertebral disc, ossification of the lateral portion may take place in the form of a half moon, the convexity turned outside. The lateral margin consists of a layer of perichondrium which becomes displaced by pressure. Instead of talking of bridges, Podkaminsky suggests the term "peridiscosis semilunaris". These changes are found mostly between the fourth and fifth lumbar vertebrae.

5. Discoligamentosis. In some diseases of the intervertebral disc, the surrounding ligaments also participate. Podkaminsky suggests the term "discoligamentosis", which may be either petrificans or ossificans. He thinks that with the progress of our knowledge his classification will have to be enlarged, but at present he considers it as the most complete.—*Ernst Freund, M.D., Venice, Florida.*

Serum Calcium, Inorganic Phosphorus and Phosphatase Activity in Hyperparathyroidism, Paget's Disease, Multiple Myeloma and Neoplastic Disease of the Bones. Alexander B. Gutman, T. Lloyd Tyson, and Ethel B. Gutman. *Arch. Int. Med.*, LVII, 379, Feb. 1936.

The calcium and inorganic-phosphorus content of the serum and the serum-phosphatase activity were determined in four cases of hyperparathyroidism, seventy-six cases of Paget's disease, six cases of multiple myeloma, and forty-five cases of neoplastic disease of the bones. The relevant data from the literature were summarized.

In classic cases of hyperparathyroidism, there is hypercalcaemia, hypophosphataemia, and increased blood-phosphatase activity. A similar state of affairs was encountered only in an occasional case of carcinoma with advanced skeletal metastases. Although studies of the blood may be of great value in confirming or excluding the diagnosis of hyperparathyroidism, the interpretation of their significance without careful consideration of the clinical and roentgenographic aspects of the case may lead to grave error.

In Paget's disease, the calcium and inorganic phosphorus of the serum may remain within normal limits in spite of extensive skeletal changes. An increase in blood-phosphatase activity, however, is demonstrable in almost all cases of polyostotic Paget's disease and remains remarkably constant for years. It is probably a result rather than a cause of the disease.

Hypercalcaemia may occasionally be present in cases of multiple myeloma. The inorganic phosphorus of the serum is within normal limits except when renal insufficiency causes retention of phosphates. The serum-phosphatase activity is usually essentially normal. The presence of hyperproteinaemia may be of value in the diagnosis of multiple myeloma.

The occasional occurrence of hypercalcaemia in cases of extensive osteolytic metastases in the bones may lead to confusion with hyperparathyroidism or multiple myeloma. Similarly, the increased serum-phosphatase activity, observed particularly in association with diffuse osteoplastic metastases in the bones, may be confused with that found in cases of Paget's disease.—*Clark W. Heath, M.D., Boston, Massachusetts.*

ZUR FRAGE DER SPONDYLOLYSIS. F. Reischauer. *Beitr. z. klin. Chir.*, CLXII, 64, 1935.

The investigations carried on by Schmorl and his pupils have given further support to the theory that spondylolysis is a congenital anomaly; as a result, Meyer-Burgdorff's conception of spondylolysis as an acquired lesion has lost considerable ground. Meyer-Burgdorff is also against the purely traumatic origin of spondylolysis, but he states that there are in the lordotic lumbar spine areas of anatomical variations in the intra-articular portion.

If one considers the question of spondylolysis from a clinical standpoint, two facts have to be mentioned which do not endorse the theory that congenital anomaly is the sole cause of spondylolysis. Bilateral separation is always present in cases of spondylolisthesis and it is also prevalent in cases of simple spondylolysis; whereas in the embryo and in infants the separation is almost always unilateral. This is not surprising because embryologically the lysis does not represent simply a maldifferentiation or retarded development, but is the anomaly of an anomaly (two bony nuclei in the lateral portion of the neural arch, instead of the normal one, and lack of fusion of the bony nuclei).

The second point is the frequency of spondylolysis. If the cause of the separate neural arch were purely congenital, one would have to expect that this condition could be demonstrated roentgenographically throughout life. The frequency of spondylolysis has to remain the same in different age groups; there can be a decline with the years only if secondary union should take place. In studying Schmorl's material, Junghanns found that spondylolysis was present in from 1 to 2 per cent. of the cases, and that males and females were almost equally affected. In a selected group of compensation cases, in which male patients predominated, Meyer-Burgdorff found the occurrence of separate neural arch to be very frequent, and this anomaly was present in 20 per cent. of the patients with injuries of the vertebral spine. Warner found this defect in 12 per cent. of the cases. From these figures alone, it would appear that there is much evidence in support of the theory of the acquired origin of spondylolysis. The typical localization of the separation in the interarticular portion cannot be taken as proof of the congenital origin because, in people doing hard manual labor, this portion is under greater stress than all other parts of the spine. If one compares the forces acting upon the posterior arch with its strength, the disproportion becomes manifest, especially in hard-working people like miners who work in the forward flexed position.

Two thousand kidney plates were studied, one-half of which were of cases in which the patients were under forty years of age. In this group, no case of separate neural arch was found; in the other 50 per cent., five cases of separation of the third and fourth lumbar vertebrae were found. (The fifth lumbar vertebra was not taken into consideration because of the flat plates.) The positive cases were all found in men doing hard manual labor.

Reischauer believes that these separations are due to an insidious process of bone transformation similar to Deutschländer's metatarsal fractures and other instances of Looser's zones of bone transformation. The congenital origin of some cases cannot be

denied, but the higher frequency of the occurrence of the anomaly in older people, especially in the hard-working class, favors the theory that spondylolysis is an acquired lesion.—*Ernst Freund, M.D., Venice, Florida.*

Osteo-Arthritis of the Hip-Joint. T. P. McMurray. *British J. Surg.*, XXII, 716, 1935.

Such great ingenuity has been shown in the classification of osteo-arthritis of the hip joint that, in many of the classifications, it is almost impossible to recognize what is after all a very common condition. The classification generally accepted is the simplest of all, the infective or toxic type, and the traumatic type.

In a study of eighty-nine cases, the author reports that the average age of onset for the bilateral cases was fifty-three years; in the unilateral group, it was thirty-four years. A large proportion of the unilateral cases were preceded by injury to the hip.

The roentgenographic appearance is usually typical, with a loss of joint space, atrophy of the bones, and a rim of osteophytic outgrowths lying around the articular margins of the acetabulum. In unilateral cases, there is usually some distinct alteration in the shape of the head of the femur, while in the bilateral cases the head remains normal in shape.

In toxic or infective arthritis there is the problem of generalized infection, while in arthritis of one hip, whether there be an infectious process present or not, it is probable that trauma or an alteration in the joint mechanism was the exciting cause, and the fear of spread of the condition is not present to the same extent.

The different methods of treatment are considered in detail and the author comes to the following conclusions: Manipulation may produce a relief of symptoms and increase movement temporarily. Arthroplasty is the ideal operation, but at present our methods and techniques fail to secure any real benefit for the patient and the operation is a failure. Arthrodesis removes the pain and deformity and greatly increases the stability of the joint, but it is a very extensive procedure and if unsuccessful results in a great increase of strain on the lumbar spine and sacro-iliac region. The bifurcation operation of Lorenz is simple, of short duration, and, if performed correctly, leads to relief of pain and deformity with no loss of stability and does not cause strain on the lumbar regions.—*Paul Siman, M.D., Iowa City, Iowa.*

The History of Plaster-of-Paris in the Treatment of Fractures. J. K. Monro. *British J. Surg.*, XXIII, 257, 1935.

At least 4,000 years ago, starch was being used in linen to give a stiffening effect for splinting.

Three phases in the use of plaster are recognized. Cheselden (1688–1752) and Larrey (about 1798) concentrated their attention on the bone. Later Seutin (1834) and Lucas-Championnière gave prior consideration to the soft parts. Movements of joints and massage were emphasized and light, portable starch apparatus was used. It remained for Krause and Böhler to point out that efficient splinting of the fracture would allow the limb to be kept constantly in use.

Matthysen in 1852 first described the use of powdered plaster-of-Paris in treating fractures. When the time came for the removal of the bandage, this was done by wetting the plaster and unwinding the bandage.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

A Further Note on the Development of Cysts in Connection with the Semilunar Cartilages of the Knee-Joint. Robert Ollerenshaw. *British J. Surg.*, XXIII, 277, 1935.

Twenty cysts in the semilunar cartilages of the knee joint are reported,—eighteen in the external cartilage and two in the internal cartilage.

Cartilage cysts may arise from the free border of the semilunar cartilage and project into the joint, producing locking symptoms and followed by effusion into the joint.

The writer believes that the smaller cysts are lined with endothelium.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

SPONDYLITIS ANKYLOPOEIETICA (SPONDYLITIS OSSIFICANS LIGAMENTOSA). F. Campbell Golding. *British J. Surg.*, XXIII, 484, Jan. 1936.

Rigidity of the spine from this condition may appear in any part, but the Marie-Strümpell type in the lumbar spine and the Bechterew type in the upper dorsal spine are the forms about which most has been written.

Infection is commonly believed to be the cause of the condition, although proof is lacking. Occupation, trauma, or strain do not appear to play a part. Males are most commonly affected, and the average age is the early thirties. The writer believes that the lesions occur first in the sacro-iliac joints; the smaller joints of the spine are then involved, with secondary involvement of the vertebral bodies and the ligaments. There is extensive connective-tissue formation with final ossification of the articular surfaces.

The writer, a roentgenologist, has collected the roentgenograms of ninety-one patients suffering from spondylitis ankylopoeietica. In every case, the sacro-iliac joints were involved, while in thirty-three cases, the sacro-iliac joints were involved, but the spine was unaffected. The symptoms in these latter patients were the same as the early symptoms in the more advanced group.

All patients gave a history of muscular and joint pains long before the onset of spinal rigidity. The author believes that the condition should be recognized earlier, that the sacro-iliac joints are the earliest clues to the diagnosis and to the degree of severity of the disease.

In some patients, the lesions burn themselves out and cease to give symptoms. Other patients get periods of relief from no treatment. Very little is said about the active treatment, but this omission is excusable because the article has been based on the roentgenographic study of the condition.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

FURTHER OBSERVATIONS ON THE DISTURBANCE OF METABOLISM CAUSED BY INJURY, WITH PARTICULAR REFERENCE TO THE DIETARY REQUIREMENTS OF FRACTURE CASES. David P. Cuthbertson. *British J. Surg.*, XXIII, 505, Jan. 1936.

The writer has previously called attention to the marked loss of body nitrogen, sulphur, and phosphorus in the urine of patients who have had severe traumatic injuries. The present paper deals with experimental work to prevent this loss.

In patients suffering from fractures of the long bones, it was found that the ingestion of a diet rich in protein and high in caloric value modified the usual loss of protein in the form of nitrogen. There was, however, no effect at the height of the catabolic process, occurring on from the sixth to the tenth day. Massage, manipulation, and the addition of meat extractives or the use of diets high in caloric value but with average protein had no effect on the usual loss.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

ISOLATED DISLOCATION OF THE BASE OF THE FIFTH METACARPAL. Norman Roberts and C. Thurstan Holland. *British J. Surg.*, XXIII, 567, Jan. 1936.

Four cases of isolated dislocation of the fifth metacarpal are recorded. But one other case has been reported previously. All were of traumatic origin. There were two types of displacement,—an extreme degree of outward displacement and a less extreme inward and forward displacement. Displacements of the latter type may be reduced easily, but continuous traction for four to six weeks is required to maintain the position. When the metacarpal is displaced outward across the palm, open operation may be necessary.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

The Pathology and Treatment of Joint Sprain. Leo J. Miltner, C. H. Hu, and H. C. Fang. *Chinese Med. J.*, XLIX, 521, 1935.

The authors have covered the subject of sprain rather carefully and have done considerable research work. They define joint sprain as a disturbance of a joint due to trauma, with the involvement of the ligaments and surrounding tendons, without fracture or dislocation. They describe two types,—mild and severe.

The mild type involves only the ligament, while the severe type involves cartilage and periosteum as well.

Their research work was done with rabbits, in which disturbances of the knee joints were produced.

In the mild type of sprain, they observed increase in amount and elasticity of the synovial fluid, hemorrhage into the loose periarticular fluid, early proliferation of fibroblasts, and fibrosis. The severe type showed also a disturbance of the articular cartilage with resulting arthritis.

The treatment advocated by the authors consists of (1) complete immobilization by cast; (2) removal of cast for physiotherapy, including heat, massage, and active and passive motion. When the pain and swelling subside, gradual weight-bearing is permitted.—*Carl Ruhlin, M.D., Iowa City, Iowa.*

Die isolierte Syphilis der Kniescheibe (Isolated Syphilis of the Patella). H. R. Paas. *Deutsche Ztschr. f. Chir.*, CCXLIV, 452, 1935.

The literature of the last twenty years contains only four cases of this rare condition.

The author reports the case of a female, twenty-nine years old, with a positive Wassermann, who had never been treated. In the spring of 1931, pain was noted over the anterior surface of the patella; there was no history of trauma. Swelling of the knee joint and weakness of the knee were evident. The symptoms subsided and recurred several times.

In December 1932, the patient was admitted to the hospital. There were no general luetic signs. Swelling, redness, and exquisite tenderness were noted over the left patella. Inflammatory capsular changes around the patella were also observed. The roentgenographic examination was negative. Six months later, there was definite apposition of the periosteal bone with sharply outlined osteophytes. Under antiluetic treatment, the condition improved in a very short time.

From his observations in this case and the reports in the literature, Paas gives the following description of the clinical picture of lues of the patella. The involvement of the peripatellar soft tissues and the anterior portion of the joint capsule is pathognomonic. The other parts of the joint are only rarely involved. The onset is insidious; the course, chronic. The clinical diagnosis is not difficult if the possibility of luetic infection is considered at all. Of differential diagnostic importance is the fact that the subchondral region remains free. The roentgenogram shows the characteristic periosteal reaction. Atrophy is practically absent.—*Ernst Freund, M.D., Venice, Florida.*

The Etiology of Chronic Arthritis. Chester S. Keefer. *New England Med. J.*, CCXIII, 644, 1935.

The author classifies arthritis as follows: degenerative arthritis, commonly called osteo-arthritis or hypertrophic arthritis; and rheumatoid arthritis, commonly called infectious or atrophic arthritis.

Although the actual etiology of the arthritides is unknown, the author offers the following as the most likely theories.

Degenerative arthritis is due to injuries, excessive wear and tear, or trauma to the articular surfaces. There are three possible theories in regard to the etiology of rheumatoid arthritis.

1. The unitarian theory in which both the rheumatoid and degenerative types are thought to be due to the same etiological agent or groups of agents. The factors which determine the type of arthritis are trauma, focal infections, menopause changes, and

habits of the patients. This is thought to be true by many authorities, as there are so many mixed types of arthritis pathologically.

2. Infectious theory. This is thought possible because of the inflammatory symptoms and the fact that there are often found positive agglutination and precipitation reactions to hemolytic streptococci. This theory has also three possibilities within itself: (a) metastasis from a focal infection; (b) toxins absorbed from a focus of infection; (c) reactions of bacteria or their end products on some sensitized tissue.

3. The eclectic theory in which there is considered an imbalance of the nervous, gastro-intestinal, and peripheral nervous systems. Gastro-intestinal disorders are commonly found with a decreased acidity, but the author does not feel that there is any definitely convincing etiological background connected with it. Very seldom does one find vascular changes in a synovium in the joints. There is rarely any connection between Raynaud's disease or scleroderma and rheumatoid arthritis. The author does not believe that there are any results obtained by sympathectomy.

In conclusion, the writer states that, although there are no definite etiological facts, there will be a better understanding of the etiology as soon as there is a better understanding of the typing of the disease.—*D. M. Fuiks, M.D., Iowa City, Iowa.*

The Importance of Trunk Muscles as Evidenced by Pool Work. C. L. Lowman. *Physiotherapy Rev.*, XV, 123, 1935.

The author stresses the value of the pool in the discovery of muscle weakness about the trunk, which cannot adequately be determined on the bed or examining table. Five reasons why the pool is of value are discussed:

1. It promotes the use of trunk muscles even while they are in a somewhat painful condition and influences the drainage of the cord where oedema might still be present.
2. It prevents disuse atrophy.
3. It allows a more adequate examination of the trunk in all planes.
4. It permits early movement of the trunk without danger.
5. It makes possible the early recognition of trunk weakness which aids in the prevention of spinal deformity.

While the patient is in the pool the special areas to be examined are the neck, thorax, abdomen, pelvis, and lower back. A number of muscles that are weakened are listed with their specific functions and the deformity which will result if they are neglected. The necessity of a careful check-up every six months over a period of three years is stressed. Also, one should not congratulate himself on a mild case until the patient has been tested in the pool for mild back weakness, 5 per cent. of which will result in deformity.—*Carl Ruhlin, M.D., Iowa City, Iowa.*

Les lésions traumatiques des ligaments croisés du genou (Traumatic Lesions of the Crucial Ligaments of the Knee). Leemans. *Presse Méd.*, XLIII, 1409, 1935.

The author believes that the unique function of the crucial ligaments is the prevention of excessive anteroposterior motion of the tibia on the femur. He considers De Rocher's "*signe de tiroir*" as characteristic but not pathognomonic of rupture of the crucial ligaments. He states that of fourteen cases reported by himself and others the sign was present in eleven and absent in three. He notes, however, that the sign may occasionally be present in the absence of a rupture of the crucial ligament and he attributes this to stretching of the ligament. On the other hand, he admits that rupture of the ligament may occur in the absence of the sign. He disagrees with the opinion expressed by others that the "*signe de tiroir*" occurs only when injuries to the crucial ligaments are associated with rupture of the lateral ligament. In support of this belief, he states that he has seen the sign in cases where the lateral ligament has been absolutely intact. On the other hand, he has not seen the sign in those cases in which unsatisfactory suture of the lateral ligament and abnormal lateral mobility have been noted after using the incision of Tavernier.—*Henry Milch, M.D., New York, N. Y.*

OSTÉOCHONDRITE DISSÉQUANTE DE LA HANCHE (MALADIE DE KOENIG). (Osteochondritis Dissecans of the Hip.) Albert Mouchet. *Presse Méd.*, XLIII, 1483, 1935.

The author takes advantage of the opportunity presented by a case report to discuss osteochondritis dissecans of the hip. He notes that the condition is at best rather unusual, that it is a disease of young adult life, and that it is characterized as follows: clinically, there is pain, a limp, or stiffness in the hip with limitation of motion, especially abduction and internal rotation in the hip; roentgenographically, the characteristic finding is that of a sequestrum at the upper pole of the head of the femur, close to the insertion of the round ligament. The condition is to be differentiated from that seen in the supernumerary ossicles about the cotyloid foramen. It is also to be differentiated from osteochondritis of the hip, Legg-Calvé disease, which is found only in young children.

No definite etiology has been described for the condition. Among the causes which have been suggested are: a single trauma, repeated minimal trauma, antecedent deformations of the head of the femur, tuberculosis, syphilis, and constitutional dyscrasias. The author expresses the opinion that gonorrhoea might occasionally be considered responsible.

Operation in the early stage may disclose nothing more than an area of softened cartilage. In the later stage, a true sequestrum will be found to have separated from the head of the femur. As in the knee joint, the treatment is operative and consists in removal of the joint mouse in order to prevent the development of a disabling arthritis of the hip.—*Henry Milch, M.D., New York, N. Y.*

DU TRAITEMENT DES OSTÉOMES (Treatment of Osteomata). J. S. Phelip and Dillensger. *Presse Méd.*, XLIII, 1499, 1935.

The authors express the opinion that osteomata are benign tumors of slow evolution, local growth, and traumatic origin, which cause local functional trouble. They consider that the trauma may be either single or repeated and that the direct result of this trauma is the formation of a hematoma which does not disappear, but which undergoes a gradual connective-tissue transformation. They are of the opinion that the transformation occurs in three stages which may be recognized roentgenographically. In the first stage, there is a large tumefaction and the roentgenogram is negative. This is the period of hemorrhage. In the second stage, the large tumefaction is present, but the roentgenogram shows signs of only a small calcium-containing neoplasm. In the third stage, the calcium-bearing area is practically of the same extent as the clinical tumor. The third stage represents the end stage in the development, while the two earlier stages represent the condition in the process of evolution. In these two earlier stages, operative intervention is contra-indicated, as well as massage or any other form of manipulative treatment. X-ray therapy alone should be employed during the first two stages and should consist of about ten to twelve radiations in a period of six to eight weeks. When the roentgenogram shows that the third stage has been reached, operation may be undertaken. By means of a gouge, the tumor should be excised completely and a portion of the normal bone should be removed. Thereafter, a short period of x-ray therapy is desirable.—
Henry Milch, M.D., New York, N. Y.

LA RÉACTION DE FIXATION DANS LA TUBERCULOSE OSTÉO-ARTICULAIRE AU MOYEN DE L'ANTIGÈNE DE BESREDKA (Compliment Fixation in Osteo-Articular Tuberculosis by Besredka's Antigen). Kurt Meyer and Mme. Froyez-Roederer. *Presse Méd.*, XLIII, 2120, 1935.

The complement fixation by means of Besredka's antigen has been shown to be positive in 90 per cent. of the cases of pulmonary tuberculosis. Mozer and Fried found it to be positive in only 70 per cent. of the cases of progressive articular tuberculosis and in only 36 per cent. of the cases of regressive tuberculous arthritis.

In their series of cases the authors employed a new egg antigen prepared by Prof. Besredka. The work was carried on in two hospitals,—one for ambulant patients and

one for bed-ridden patients. With but slight modification, the technique was that employed by Besredka and described by Rubinstein. Three hundred and twenty-two reactions were studied. Of these, 124 were in patients with tuberculous lesions; fifty-two were in patients considered cured; and 146 were in non-tuberculosis patients used as controls. The authors divide the known tuberculous patients into age groups as follows: (1) up to six years of age; (2) between six and sixteen; (3) over sixteen. In general, they have found that the reactions tend toward a higher percentage of positives in the older age group than in the younger age group. In the older age group, the percentage of positives ran as high as 88, while in the total group of 124 individuals, the average was only 76.6 per cent. positive. In the non-tuberculous group of 146 patients, positive reactions were obtained in six or 4.1 per cent.

It appears that the test is more certainly positive in Pott's disease of the spine and in tuberculosis of the hip than in other types of osteo-articular disease. The authors are of the opinion that, in the presence of a positive reaction, they can state with certainty that there is an active process present. However, the negative reaction would be of value in excluding the presence of tuberculosis only in patients over the age of sixteen. In view of the fact that the percentage of positive results apparently diminishes with the duration of the cure, even in adults, the authors believe that the test may have some prognostic significance. This, however, is being studied further.—*Henry Milch, M.D., New York, N. Y.*

LA MALADIE DE VOLKMANN. RÉTRACTION ISCHÉMIQUE DES MUSCLES FLÉCHISSEURS DES DOIGTS. PATHOGÉNIE. TRAITEMENT. (Volkmann's Contracture. Pathology and Treatment). Raphaël Massart. *Rev. d'Orthop.*, XXII, 385, Sept. 1935.

In this article, written at the request of the Société Française d'Orthopédie, a comprehensive review of the present-day knowledge of Volkmann's contracture is recorded. It is pointed out that the condition is an evolutionary disease, starting with a necrotic muscular lesion and resulting in localized ischaemia and fibrosis which lead to vasomotor troubles and all the picture of Volkmann's contracture. There are three main causative factors: bone injury, too tight apparatus, and hemorrhage into tissue. Trauma of reduction may at times be the initial insult. Though the condition may occur in the absence of splinting, it is wrong to neglect this factor. In the acute form, with the vasomotor disturbances and nerve ischaemia, vascular troubles are of the first order. Injury to the blood vessels, not a hematoma, causes the absent radial pulse and the cold anaesthetic hand. The signs come on during the first hours and the damage occurs early, not late. Early and liberal operation is indicated. There is a chronic form in which the characteristic signs develop late, after a few weeks or months. The ischaemia and paralysis eventually develop with fibrosis of the muscles and adjoining tissues. If taken in time, something can be done for this group of patients,—sympathectomy and cutting of the arteries. If instituted too late, the above treatment does not suffice. The reaction is not reversible. Then there remain only the reconstructive procedures of the orthopaedic surgeon.—*Stephen G. Jones, M.D., Boston, Massachusetts.*

END RESULTS OF LEG LENGTHENING. G. Bruce Stephenson and Herbert A. Durham. *Southern Med. J.*, XXVIII, 818, Sept. 1935.

This report is based on seventeen cases. In two cases, lengthening of the femur was done, and in fifteen cases, lengthening of the tibia and fibula was carried out. In each case, the shortening was the result of poliomyelitis. None of the patients was under twelve years of age.

The technique and the apparatus are described in detail. With the type of apparatus used, frequent roentgenograms are not necessary; thus the danger of delayed union is avoided. The time required for lengthening is fifteen to twenty-five days. The lengthening apparatus is left on for from four to five weeks. A cast is then applied, followed by the use of a walking caliper.

In each case solid union was obtained in six to eight months. The minimum tibial

lengthening was one and three-fourths inches; the maximum, two and three-fourths inches. One femur was lengthened two and three-fourths inches; the other, three and one-fourth inches.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

SYNOVECTOMY OF THE KNEE JOINT IN CHRONIC ARTHRITIS. Solomon D. David. *Southern Med. J.*, XXVIII, 867, Oct. 1935.

The author reports ten cases in which eleven synovectomies were performed. The results were as follows: excellent, in nine cases; fair, in one case; and failure with ankylosis, in one case. The patients were carefully selected and the end results seem to justify the operation. Conservative methods should always be tried first, but they should not be persisted in too long.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

OPEN REDUCTION FOR FRACTURES AND DISLOCATIONS: INDICATIONS AND METHODS. Howard R. Mahorner. *Southern Med. J.*, XXVIII, 993, Nov. 1935.

Open reduction is the method of election in cases of fracture of the patella or of the olecranon with wide separation of the fragments, depressed fractures of the skull, and fracture of the neck of the femur in the aged. In the latter type, fixation is obtained by wood screws.

Open operation is also indicated in cases of fracture or dislocation which cannot be satisfactorily reduced by other methods, as well as in cases of malunion and non-union. One-fourth of the cases requiring open reduction are due to faulty initial treatment. The Lane technique diminishes the incidence of infection. Prolonged immobilization gives better end results than the early removal of splints and the use of physiotherapy, except in fractures into the joints and in elderly people.—*F. G. Hodgson, M.D., Atlanta, Georgia.*

WELL LEG TRACTION AS AN AID IN THE CORRECTION OF SOME STEREOTYPED ORTHOPEDIC DEFORMITIES. J. Warren White. *Southern Med. J.*, XXIX, 45, Jan. 1936.

Besides the employment of this apparatus in fresh fractures the author has found other uses.

After a hip fusion it is of value in maintaining abduction; only minimal traction is applied. The apparatus also aids in correcting lateral curvature of the spine by maintaining a tilted position of the pelvis. It is also used to correct adducted hips which cannot be corrected following manipulations or osteotomies, in spite of extensive myotomies and capsulotomies. It is of particular value in cases of poliomyelitis with bilateral hip flexion; however, care should be taken not to dislocate the adducted hip. This apparatus is also of great aid in cases of acute suppurative arthritis, especially in desperately ill patients and as an immediate postoperative dressing of an arthroplasty of the hip.

In many cases of pathological dislocation of the hip reduction will take place spontaneously—that is, without manipulation—when this apparatus is used. It also permits contracted scars to be stretched. This apparatus may be used in reverse—that is, to cause pressure instead of traction—and may be employed to insure good approximation after resection of the knee. Too much pressure should not be used, as it has been found by Key to be harmful.

The disadvantages of this apparatus are also mentioned.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

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THE PRESIDENT'S ADDRESS

The Rôle of Physical Therapy in Orthopaedic Surgery *

BY FREDERICK J. GAENSLEN, M.D., MILWAUKEE, WISCONSIN

Physical therapy, the oldest form of treatment of the sick and injured, should need no one to champion its cause; nor would this be necessary had not unwarranted claims for agents as yet little understood brought disfavor upon the subject as a whole. Well-informed physicians know that heat, massage, water, and exercise are still the mainstays of physical therapy and that the mysterious and high-priced devices for the administration of some of the newer agents are still largely in the experimental stage, are of limited usefulness, and are often greatly overrated. Partial truths have been magnified both by cultists, endeavoring to build up a system of the cure-all type, and by members of the profession, guilty of unwarranted optimism. Small wonder that the better element in the profession has shown a tendency to refrain even from the legitimate use of the newer agents, in order to avoid the suspicion attached to those employing these methods promiscuously and without proper attempt at evaluation.

Since the work of the orthopaedic surgeon deals very largely with the function of the locomotor apparatus, and since physical therapy ministers to a large proportion of patients with dysfunction of the locomotor apparatus, there is perhaps a closer relationship between physical therapy and orthopaedic surgery than between physical therapy and any other specialty. It therefore behooves us as a group to recognize not only the virtues but also the limitations of physical therapy, in order that this important branch of therapy may be included in our program of treatment when indicated, and also that the younger men coming under our influence may be given an opportunity to form their own opinions from observation of the use of these measures in impartial hands rather than from the sales talks of manufacturers' agents.

* Presented at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 19, 1936.

The older and simpler forms of physical therapy have been found useful from time immemorial. In this group belong rest, heat, light, massage, and exercise. Until recently some of these agents were employed largely on an empiric basis, but as our knowledge increased sound scientific principles were found to underlie their use. The difficulty with some of the newer agents is that not enough clinical evidence is available to justify them, even on an empiric basis. Our attitude toward this type may well be one of benevolent neutrality, at least until clinical evidence in sufficient volume from well-qualified, unprejudiced investigators is available, even although science may be slow in providing logical explanations.

It will be of interest to consider the various agents and to determine to what extent they are based on sound principles.

REST

The need of rest to the injured part in the case of a fracture is self-evident to allow the repair process to go on without interruption. The initial process of repair may be visualized as an attempt on the part of newly formed connective tissue and the accompanying vessels to bridge the gap between the fragments. If these attempts are constantly aborted, repair cannot take place. In the acute inflammatory process, rest is necessary to avoid dissemination of the invading organisms along fascial planes and tendon sheaths, with a breaking down of nature's barriers of defense and the exhaustion of efforts at repair. The frequent occurrence of non-union, due to insufficient fixation, and the spreading of an infection, as a result of injudicious use, may serve as clinical evidence of the value of rest in the conditions named. In infantile paralysis and in peripheral-nerve injury, the use of rest, with the involved muscles in the position of relaxation, is axiomatic. In these and many other conditions, rest is an indispensable part of the recovery program.

HEAT

It is generally accepted that heat causes relaxation of tissues, relief of muscle spasm, increased blood supply, and, consequently, improved nutrition. Goldschmidt and Light, in studying the effects of local heat on blood chemistry, found that the venous blood returning from the heated part showed diminished oxygen content, while the carbon-dioxide and lactic-acid content was increased. In other words, warmed tissues withdraw and use oxygen in greater amount, while waste products and presumably toxic material, if present, are eliminated more efficiently. That adequate blood supply favors defense against infection and promotes repair and growth of tissues is proved by abundant clinical observation. In this connection, the work of Brown and Roth on the physiological changes in blood, due to exercise and variations in environmental temperature, is interesting and enlightening. They found that normally the oxygen saturation of venous blood is 70 per cent. During exposure to cold, the number of open capillaries is decreased, the rate of flow is dimin-

ished, and the metabolism of the tissue is inhibited. The rate of exchange between the blood in the capillaries and the tissues is decreased, as evidenced by the fact that the blood entering the veins contains 75 to 80 per cent. of the saturated value. After local application of heat, the number of open capillaries is increased, the rate of flow and tissue metabolism is accelerated, and the rate of exchange between the blood and tissues rises to its optimum. As a result, the blood entering the veins contains only from 60 to 65 per cent. of its saturated value of oxygen.

MASSAGE

Massage as a therapeutic measure is universally accepted and widely employed. In treating recent injuries, following the teaching of Championnière, Mennell, and others, massage should be very light and rhythmic. If so administered, it is helpful in relieving pain and in relaxing muscle spasm, as well as spasm of vessel walls. As a consequence of this relaxation, there is a markedly increased flow of blood and lymph, with a resulting increase in local metabolic activity, conducive to tissue repair. This stimulating effect on the circulation is commonly regarded as a reflex effect, proof of which may be seen in the moving-picture film prepared by Clark and Swenson, which shows the capillary circulation in the rabbit's ear. Gentle stroking of the ear was followed by marked widening of the capillaries and a tremendously increased rate of flow. As the stroking was so light that mechanical emptying of the veins could be excluded, the reflex nature of the stimulation seems apparent. In the later stages of fractures, sprains, and other injuries in which persisting oedema obstructs venous return, deep massage, always in the direction of the venous flow, is indicated for the removal of exudate and waste products. As the veins are emptied by pressure, there is a rapid refilling from the capillary and arterial side, resulting in definite improvement of local nutrition. Preliminary heating or heating during the period of massage is of added value, as is also elevation of the part in order to secure the benefit of gravity in emptying engorged vessels.

EXERCISE

Active exercise is perhaps the most valuable of all forms of physical therapy, because it calls into play the entire neuromuscular apparatus. This apparatus consists of three distinct parts:

1. The upper and lower motor neurones and the contracting muscle cell;
2. The inhibitory mechanism providing for finely graduated, precise movement;
3. The mechanism insuring relaxation of antagonistic muscles.

Thus the voluntary effort involves function of the entire complicated mechanism, which cannot be claimed for any other form of physical therapy. Accompanying muscle contraction there is compression of the lymphatic and venous channels, while during muscular relaxation these

vessels fill rapidly from the capillary side. Stasis is overcome and acceleration of the blood stream must result. Clinical evidence of the results of diminished blood supply is afforded by the pale muscle of the paralytic limb, the decalcified bone in disuse, and the cold extremity following inactivity. Biomicroscopic evidence is afforded by the work of Brown and Roth, who found that during exercise the number of open capillaries per square millimeter of skin is greatly increased, while other investigators showed that in the normal active individual the capillaries in the nail bed are closely packed in hairpinlike loops, while those of the inactive arthritic hand are much less numerous and narrower, indicating a diminished blood supply.

In the healing of fractures early motion is desirable, because motion causes pressure on the immature callus and pressure exerts a trophic influence, favorable to ossification. This explains the value of limited weight-bearing in delayed union; but internal stress on the bone, as Carey has shown, may be brought about by muscular contraction, a dynamic force, as well as by the static force due to transmission of body weight. In fact, the dynamic stress due to muscular contraction may far exceed the static stress. As long ago as 1894, Roux called attention to the facts that functional stimuli have trophic effects, that under the influence of tension young connective tissue is transformed into strong fibrous tissue, and that pressure, either alternating with tension or without tension, produces bone. In his admirable book on bone formation, Jansen goes a step farther and brings evidence to prove that, contrary to Wolff's law, bone is laid down not in response to trophic stimuli of both tension and pressure but to pressure alone. He states that fibrous tissue which has been submitted to tension remains fibrous throughout the life of the individual. That fibrous tissue, interposed between fracture surfaces, can be transformed into bone or replaced by bone, if the shearing force is eliminated, has been proved by the writer in experimental work on the dog. In a number of dogs the neck of the femur was cut through with a chisel and a full-thickness flap of capsule, completely covering the fracture surfaces, was interposed. Reduction was maintained by internal fixation secured by three knitting-needle spikes. Tension or shearing force was thus replaced by pure stress or pressure, and, in the five cases in which healing was allowed to progress for four months or longer before the animals were sacrificed, bony union resulted. In fractures of the ribs, where apposition is secure and function is uninterrupted, due to respiratory movements, healing takes place in a minimum of time. The closer we can approach this ideal of accurate reduction and uninterrupted function, the happier will be our results in fractures. Sling-suspension exercises, balanced traction and other similar devices, under-water exercises, in short, any method which will allow motion of the neighboring joints at an early date without jeopardizing the position of the fragments, should be utilized in the treatment of fractures. Murray and others are of the opinion that not infrequently disability after injury may be prolonged by the patient's

reliance on the physiotherapist to bring about his recovery by the application of some of the newer so-called modalities, with the resultant comparative neglect of the much more important voluntary effort in the rehabilitation program. The surgeon will do well to devote some time to the provision and proper arrangement of simple apparatus and to the supervision of at least the initial efforts of the patient. "Muscle setting", or static exercises with the limb still in plaster or splint, is also valuable, not only in diminishing joint stiffness, but in providing the trophic stimulus conducive to bone formation as a result of the dynamic stress.

OCCUPATIONAL THERAPY

Occupational therapy deserves special mention. When properly employed, with active exercise its basic principle, it is without doubt one of the most valuable adjuncts to physical therapy. If the program for the individual patient is carefully thought out and work properly planned and graduated, the injured are restored earlier to mental and physical fitness. While hospitals generally should be equipped at least to initiate this form of treatment, the community workshop with highly trained personnel will solve the problem for the more difficult cases.

POSTURE

In the reconstruction program the question of posture is often given insufficient consideration. This holds true for the position of the part, which often results in preventable deformities and disabilities such as adduction contracture of the shoulder and drop-foot, as well as for the body as a whole. It is deplorable to see crippled arthritics hunched up in bed or in wheel chairs, exemplifying every vicious feature of defective posture. Swaim has demonstrated before this organization how much can be accomplished by way of correction and how important this correction is in the general physiology. If prophylaxis were properly stressed, many of the most severe deformities could be avoided. The deformities in the arthritics and in many other patients can be predicted with considerable accuracy and in a large part prevented by postural measures. Among such measures the prone-lying position deserves special mention, because of its effect in simultaneous correction of flexion contractures of both hips and knees.

IRRADIATION AND DIATHERMY

I have dwelt at some length on the simpler forms of physical therapy, because in the conduct of our own work all other forms combined have not contributed more than about 10 per cent. of the total effort in this direction. We still have a great deal to learn concerning the fundamental effect on physiological and biological processes of the various forms of radiation. As regards ultra-violet radiation, we know only that it will cure rickets and promote the development of sound bones and teeth. The misuse of this agent has led several large insurance companies in this state to discourage the use of ultra-violet radiation in industrial cases.

Time will not permit discussion of radiotherapy, involving the use of the roentgen-ray and of radium. Fortunately, this form of therapy is very largely in the hands of a comparatively few highly trained physicians, to whose judgment most of us will be very happy to defer on special occasions when radiosensitivity of bone tumors and like problems present themselves.

As to diathermy, I will quote Coulter: "Well-established evidence indicates that local application of heat is effective as an adjunct in the treatment of certain traumatic and inflammatory changes in bones, bursae, muscles, ligaments, and tendons. Both long and short-wave diathermy are effective methods of applying heat and can be used to advantage for many of these conditions. There is no available evidence that medical diathermy has any effect other than that due to heat produced."

CONCLUSIONS

In general, one may say that too much emphasis cannot be laid on diagnosis, that the burden of proof rests on him who advocates the widening of the scope of physical therapy, and that, in the absence of proof, conservatism and a careful guarding against unwarranted enthusiasm are indicated.

Scientific evidence and clinical proof must come from well-trained and tried impartial investigators who are in a position to give us results of treatment, checked up by suitable controls. We will not look for this evidence in the reports of enthusiasts and optimists and we have no patience with those who continue treatment over interminable periods, finding their patients a little better each day, only to have a careful checking up show the condition unchanged.

The stocking up of the office of the young physician with expensive equipment of limited and doubtful value may bring him to the "cakes and ale stage" in a shorter time, but the price paid is not measured in dollars and cents. We need more men who will devote themselves earnestly to the basic problems involved, and more well-staffed and well-equipped institutions where diagnosis is taken seriously and where results are carefully observed, to help in the process of more clearly defining the legitimate field of the various agents and to restore physical therapy to the dignity it deserves.

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FRACTURES OF THE OS CALCIS

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Any discussion of fractures of the os calcis can be undertaken only by acknowledging that there exist two distinct schools of thought in regard to the best method of treatment of this disabling condition. It is only by weighing these fundamental differences that one can conclude that certain procedures and steps in the treatment will produce an end result which will give a maximum restoration of function. The work of Böhler represents the greatest single contribution ever made toward the care of these fractures, and, having been privileged to follow closely his work, it has seemed to the author that this closed method of treatment offers distinct advantages over the various open types of reduction and arthrodesis that are advocated by others. Accordingly, at Boulder Dam the principles of the Böhler regimen were instituted and carried out in all of our cases. All treatments were given in our own hospital at Boulder City. These compensable industrial injuries were followed from the time the accident occurred until there had been complete healing and the patient had returned to work. When further improvement could not be obtained and when the condition of the cases was stationary, they were submitted for disposition to the Industrial Commissions of the States of Nevada and Arizona, who then estimated the percentage of disability. This rating,

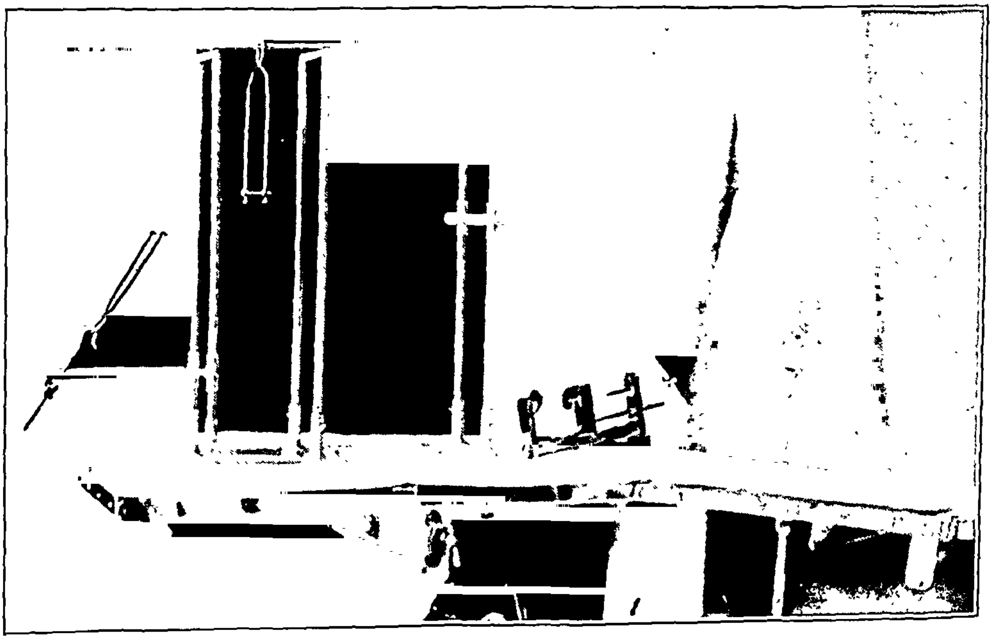

FIG. 1

Compression clamp and Böhler frame.

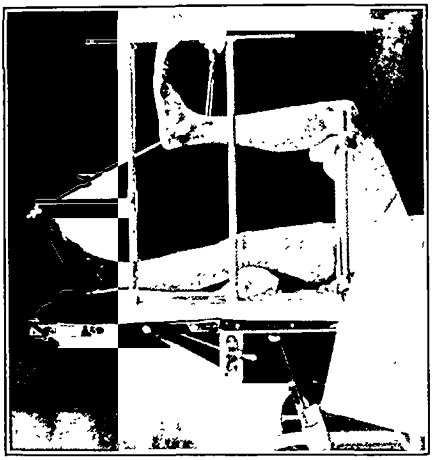

Fig. 2
Patient in Böhler frame.

Fig. 3
Illustrating use of compression clamp.

therefore, was made only when it had been established that the maximum restoration had been accomplished.

INCIDENCE

The total number of fractures which occurred, and upon which we have complete records, is 2,025. The incidence of occurrence of lesions of the os calcis was 2.56 per cent. The series comprises fifty-two consecutive cases and includes every case that occurred on the project. Of these fifty-two cases, 65 per cent. were caused by a fall and 35 per cent. by a blow. The average age of our patients was thirty-one years, the oldest

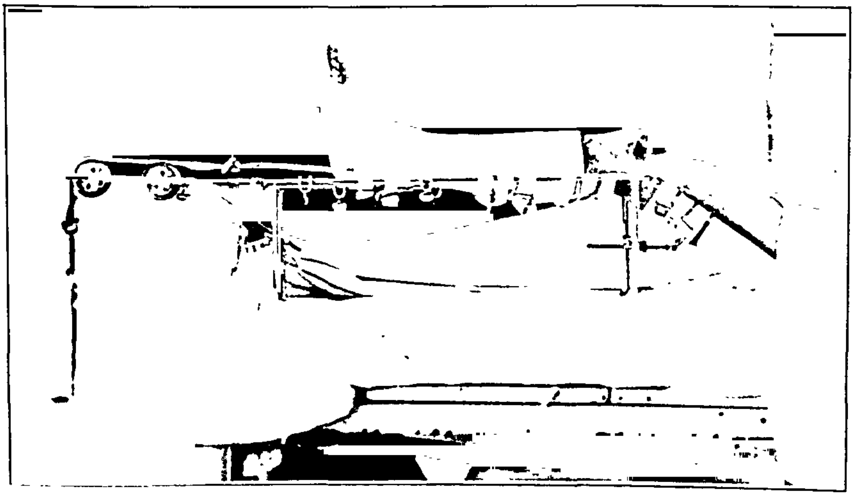

Fig. 4
Patient in Braun frame.

eing fifty-two years and the youngest eighteen years. Four atients, or 8 per cent., had bilateral fracture of the os calcis. Twenty-ve per cent. of the fractures of the os calcis were associated with ther fractures of the ankle or foot; 12 per cent. were associated with ertebral fractures; and 1 per cent. were compounded.

PROCEDURES

Upon the occurrence of an accident, the injured man was moved nly far enough away from the scene to be out of further danger (never ore than a few feet). He was then promptly cared for by a compe-nt first-aid attendant who made sure that rapid ambulance transporta-on would be accomplished without any disturbance to the injured parts. The patient usually arrived at the hospital in thirty minutes and not longer than sixty minutes after the accident occurred. While the radiographer was obtaining roentgenograms, an assistant doctor was present to care for the injured extremity and to attend to any other considerations that might be indicated for the patient's welfare. Views of the injured foot were made in the anteroposterior and lateral positions, and an axial view was made of the os calcis; corresponding views of the uninjured foot were obtained for comparison, and further special detailed views were always taken when they were needed to clear up some apparent diagnostic uncertainty. Roentgenograms were made of the back when pain was complained of that area, and, during the treatment of the last third of this series of ses, x-rays of the lower dorsal and the lumbar vertebrae were routinely ken, because of the often existent and too often overlooked concurrent jury of these parts.

Fig. 5

Showing walking stirrup in-orporated in cast.

CLASSIFICATION

The types of fractures encountered, together with the number and ercentage of each, and the treatment afforded in each instance, are dis-ussed in the following analyses:

TABLE I

Type-I Fracture

Time in Hospital	Complications	Cast Worn	No Weight-Bearing	Time Off	Time Rated	Functional Loss
11 days	None	14 weeks	2 months	5 months	8 months	6 per cent.

Type I

This is the so-called avulsion fracture with medial displacement of the sustentaculum tali, which occurred in only one instance, or 2 per cent. of the cases. The treatment consisted of compression made directly over the displaced fragment and the application of a cast with the foot inverted and dorsiflexed.

Type II

This is fracture of the body with no displacement of fragments, which does not involve any articular surfaces, and which causes no disturbance in the salient angle*. This type occurred in one instance, or 2

FIG. 6-A

FIG. 6-B

FIG. 6-C

FIG. 6-D

Fig. 6-A: Case 1. Initial lateral view of right foot.
Fig. 6-B: Case 1. Initial axial view of right foot.
Fig. 6-C: Case 1. Lateral view of right foot, showing end result.
Fig. 6-D: Case 1. Axial view of right foot, showing end result.

* This salient angle (Fig. 11-C) or tuberosity-joint angle is a designation coined by Böhler that is graphically represented by the projection of two intersecting lines,—one drawn through the superior aspect and the anterior-superior angle of the bone, the other drawn through the same superior aspect and the uppermost border of the tuberosity.

per cent. of our cases. Treatment consisted of the application of a cast, with the foot in midposition and in dorsiflexion.

TABLE II

TYPE-II FRACTURE

Time in Hospital	Complications	Cast Worn	No Weight-Bearing	Time Off	Time Rated	Functional Loss
4 days	None	1 month	2 months	3 months	6 months	0

Type III

This type includes fractures of the medial process of the tuberosity. It occurred in seventeen instances and comprised 33 per cent. of the fractures found in this series. In each case the injury was caused by a vertical fall and the appearance of the lesion is shown in Figures 6-A, 6-B, 7-A, and 7-B.

After the site of fracture had been injected with 2 per cent. novocain, the soft-tissue swelling was molded out and the fragment or fragments were returned to their anatomical position by using the Böhler compression clamp. Check-up roentgenograms were taken and an unpadded

TABLE III

TYPE-III FRACTURE

Time in Hospital	Complications	Cast Worn	No Weight-Bearing	Time Off	Time Rated	Functional Loss
(Days)		*(Weeks)*	*(Months)*	*(Months)*	*(Months)*	*(Per Cent.)*
15	Foot and spine	8	3	4	7	3
3	None	8	3	5	6	0
3	None	6	4	6	12	0
0	None	8	2	3	10	0
36	None	10	5	9	10	10
14	Foot	8	3	6	7	0
14	None	6	3	6	10	12
0	None	6	2	3	5	0
5	Spine	8	3	5	6	2
15	Foot and spine	6	3	4	7	2
4	None	4	1	2	3	0
2	Spine	8	3	6	9	3
0	None	6	3	5	8	0
42	None	8	3	5	14	5
14	None	8	2	4	6	0
8	Foot	8	3	4	8	3
42	None	6	3	4	14	0
Average 13 days		7 weeks	3 months	5 months	8.3 months	2.3 per cent.

cast was applied from a point just below the knee to one-half an inch beyond the large toe, with the foot in midposition and in dorsiflexion. Occasionally, a walking stirrup was applied immediately, but more often this was deferred several days, during which time the patient remained hospitalized with the injured foot in the elevated position.

This group is summarized in Table III, and the end results are illustrated by Figures 6-C, 6-D, 7-C, and 7-D.

Type IV

This type includes the fractures of the trochlear process and those of the anterior portion of the body of the bone which involve the cuboid articulation and possibly the minor anterior facet of the astragalus. The salient angle was very seldom disturbed and there was no injury to the tuberosity. The injury received was always a direct blow; in many instances, the anterior half of the foot was in a fixed position and the blow came from the side to the heel portion which was not in a fixed position. The group comprised ten cases, or 19 per cent. of the series, and the pathology of this type is shown in Figures 8-A, 8-C, 8-E, 9, and 10.

In three of these cases reduction was obtained by the screw-traction apparatus. In the other seven, the fractures were reduced by manual traction on the heel, which was sufficient to separate the articular facets and to produce a reposition of the impinged fragments. An unpadded cast was applied from the knee to the toes and the walking stirrup was placed on the cast, usually on the second day.

The group summary is contained in Table IV, and the end results are shown in Figures 8-B, 8-D, and 8-F.

TABLE IV

TYPE-IV FRACTURE

Time in Hospital	Complications	Cast Worn	No Weight-Bearing	Time Off	Time Rated	Functional Loss
(Days)		*(Weeks)*	*(Months)*	*(Months)*	*(Months)*	*(Per Cent.)*
5	Foot	4	2	4	6	0
12	Ankle	8	3	5	9	0
14	Foot and spine	4	2	4	18	5
12	None	2	1	2	8	0
2	None	2	1	1	2	0
1	None	3	2	3	4	3
1	Ankle	4	2	4	10	12
5	None	8	2	3	9	0
1	None	0	0	1	6	0
2	None	4	2	2	3	0
Average 5 days		4 weeks	1.7 months	3 months	7.5 months	2 per cent.

Type V

This type comprises comminuted fractures of the body with displacement and oftentimes compression and impaction of the fragments. In our series, these fractures always involved the subastragaloid joint and usually the cuboid articulation, and the whole architecture of the bone was altered (Figs. 11-A and 11-B). There is a disturbance made in the salient angle. Normally this angle is about 27 degrees, but with this type of fracture it is decreased, or may be obliterated, or entirely reversed (Fig. 11-A). This group included twenty-three cases, or 44 per cent. of the series. The cause of the injury was a vertical fall in eighteen instances and a direct blow in five instances. This type of fracture affords the classic illustration of the principles of the Böhler technique, which makes use of the skeletal transfixion pins, the compression clamp, and the screw-traction frame (Fig. 1). The summary of these cases is shown in Table V.

TABLE V

TYPE-V FRACTURE

Time in Hospital	Complications	Cast Worn	No Weight-Bearing	Time Off	Time Rated	Functional Loss
(Days)		*(Months)*	*(Months)*	*(Months)*	*(Months)*	*(Per Cent.)*
60	None	3	5	8	10	18
35	None	3	5	8	14	20
35	None	3	4	5	8	5
40	None	5	5	7	9	8
60	Spine	4	5	8	11	7
10	Foot	3	6	13	16	15
64	None	3	5	7	12	10
30	None	2	3	4	5	0
70	Foot	3	4	8	10	10
10	None	2	4	10	18	20
2	None	2	3	5	6	0
15	Ankle	3	4	6	12	5
3	None	3	2	3	6	0
30	None	4	4	6	8	10
30	None	1	4	7	12	10
30	None	2	3	6	7	3
30	None	3	5	6	8	5
30	Ankle	2	4	8	14	10
35	None	3	4	6	8	5
30	Foot	2	4	5	9	18
40	None	4	5	8	9	10
Average 33 days		11 weeks	4 months	7 months	10 months	9 per cent.
17 months	Osteomyelitis	1 month	12 months	2 years	2 years	25
17 months	Osteomyelitis	3 months	16 months	2 years	2 years	55
Average 74 days		11 weeks	5 months	8.3 months	11 months	12 per cent.

These fractures were reduced as soon as possible after the injury occurred, and in many instances only a moderate swelling had opportunity to take place. The usual time which elapsed between injury and reduction was less than sixteen hours; the shortest time was three hours and the longest was seven days.

Anaesthesia was obtained by dissolving 100 to 150 milligrams of novocain directly in the spinal fluid, after which the lower leg was cleansed with soap and water, alcohol, and ether.

An attempt was then made to break up any impaction, and the swelling around the ankle and heel was ironed out.

There must be a reposition of the fragments in such a manner as to insure a return of the normal salient angle, which is determined in a lateral roentgenogram, and to correct the widening out that occurs in the plantar

FIG. 7-A

FIG. 7-B

FIG. 7-C

FIG. 7-D

Fig. 7-A: Case 2. Initial lateral view of left foot.
Fig. 7-B: Case 2. Initial axial view of left foot.
Fig. 7-C: Case 2. Lateral view of left foot ten months after injury.
Fig. 7-D: Case 2. Axial view of left foot ten months after injury.

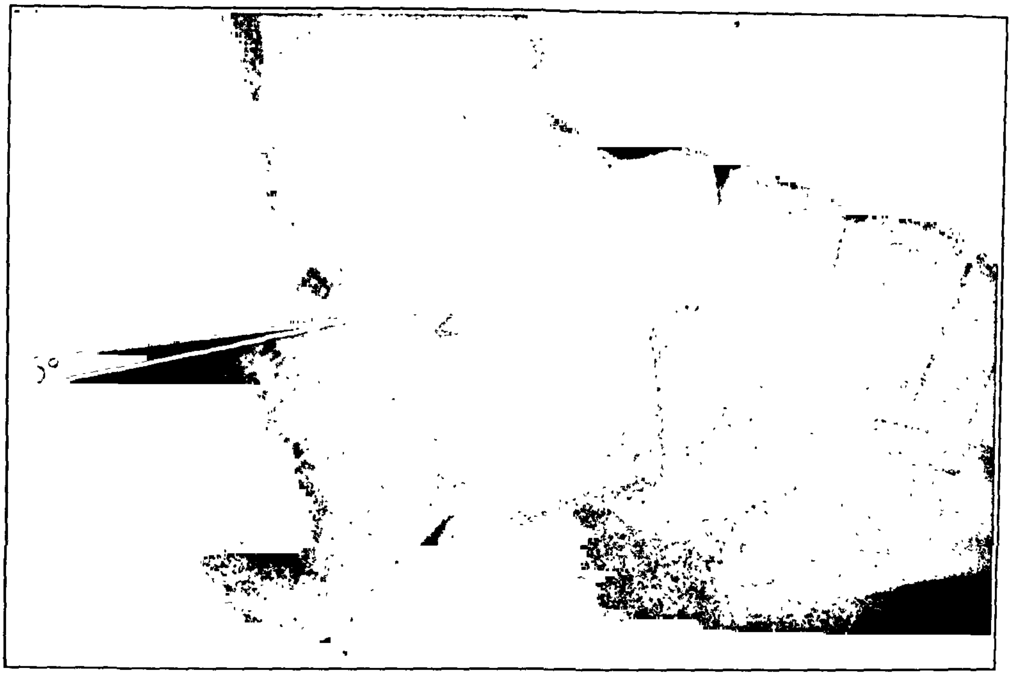

FIG. 8-A

Case 3. Initial lateral view of left foot.

surface of the heel, as shown in the axial view. Fulfilment of these two requisites is essential to minimize or to prevent functional loss.

The skin at the site of introduction of the solid Böhler pin (three-sixteenths of an inch) into the os calcis was painted with 3 per cent. iodine solution (one-half tincture strength). With the foot in dorsiflexion, the pin

FIG. 8-B

Case 3. Lateral view of left foot seven months after injury.

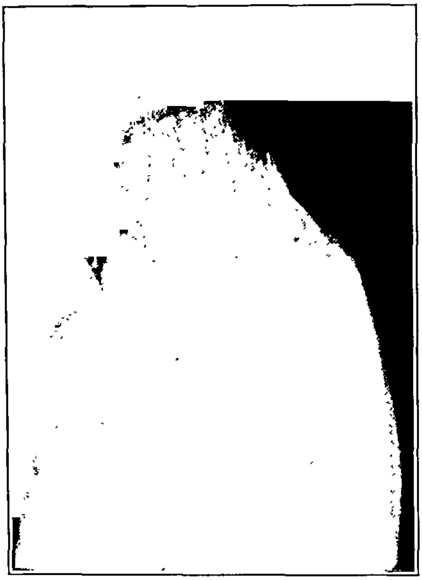

FIG. 8-C
Case 3. Initial axial view of left foot.

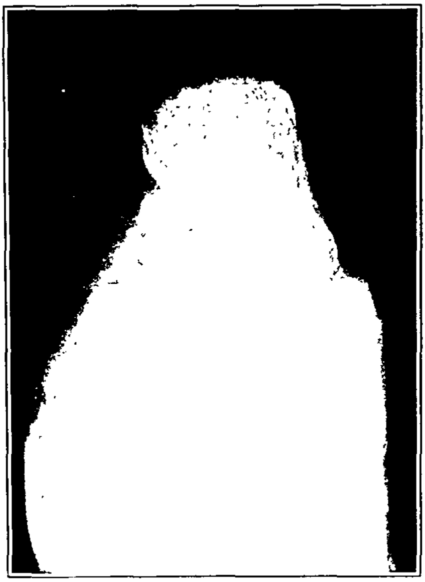

FIG. 8-D
Case 3. Axial view of left foot seven months after injury.

FIG. 8-E
Case 3. Initial anteroposterior view of left foot.

FIG. 8-F
Case 3. Anteroposterior view of left foot seven months after injury.

FIG. 9
Case 4. Lateral view of left foot.

FIG. 10
Case 5. Lateral view of right foot.

was driven through the heel bone and the U tractor was applied. On more than one occasion, as the process of reduction proceeded, it was necessary to remove the pin and to replace it in a slightly different position in order to get the proper pull to bring about the best realignment of the several fragments when traction was applied. In two cases, the point of pin insertion was between the bone and the tendo achillis, because this point of application of traction produced the best anatomical reposition of the fragments. The tibial pin was introduced in a like manner and the U tractor was applied. With the knee flexed, the leg was placed in the extension frame (Fig. 2) and traction was provided in the exact manner so often described by Böhler. This was followed by the use of the compression clamp (Fig. 3). Check-up roentgenograms were taken, and, when the salient angle was restored and reposition of the fragments was obtained (Figs. 11-C and 11-D), the cast was applied. The cast extends from a point two inches below the proximal fibular head to one-half an inch beyond the end of the large toe, the foot being in midposition and dorsiflexed never more than to a right angle. Another check-up roentgenogram was taken, after which the tibial pin was removed, the patient was returned to his room, and the leg was placed on the Braun frame with a seven-pound weight attached to the U tractor on the os-calcis pin (Fig. 4).

When such a fracture is reduced and the foot is immobilized in an unpadded plaster cast, it is highly important that the toes be checked every hour or so during the first twenty-four hours to detect any nerve or ischaemic disturbances. Seldom was it necessary to bivalve the whole cast, but very often the cast was cut over the dorsum of the foot or split

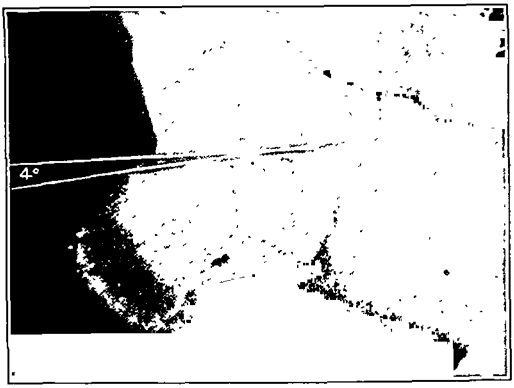

Fig. 11-A

Case 6. Initial lateral view of left foot.

Fig. 11-B

Case 6. Initial axial view of left foot.

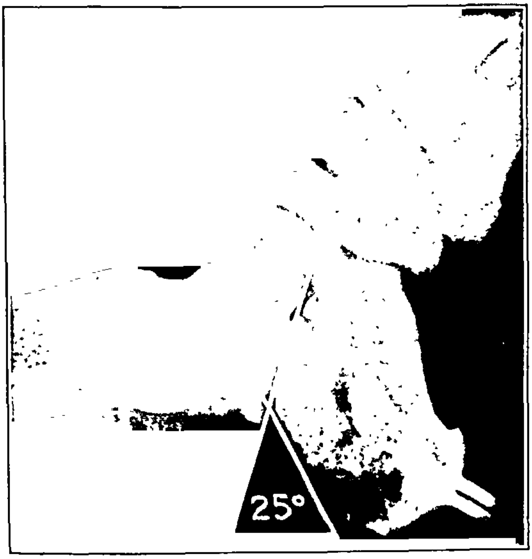

Fig. 11-C

Case 6. During reduction in Böhler frame.

Fig. 11-D

Case 6. After compression clamp has been applied.

Fig. 11-E

Case 6. Lateral view six months after injury.

Fig. 11-F

Case 6. Axial view of left foot six months after injury.

over its uppermost portion toward the knee. Complete removal was necessary in two instances, in both of which a second cast was applied in twenty-four hours. These are daring procedures when a non-padded cast is used, and they certainly court disaster if experienced nurses and

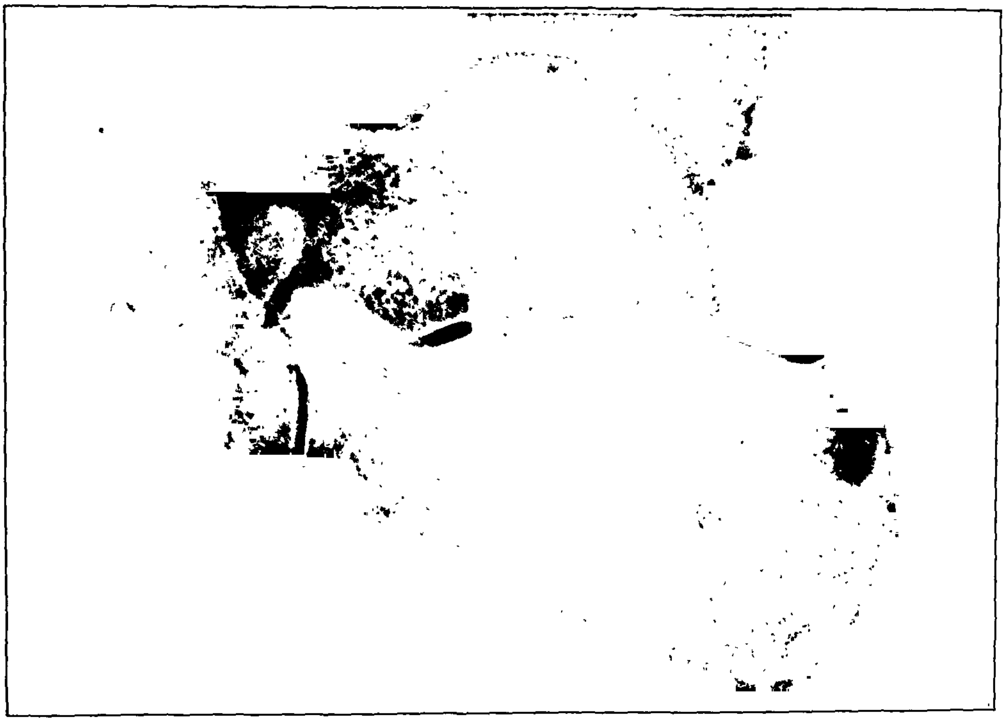

FIG. 12-A

Case 7. Lateral view of right foot nineteen months after injury.

FIG. 12-B

Case 7. Lateral view of left foot nineteen months after injury.

assistant doctors are not constantly observing the condition of the extremity. The cast was routinely removed and the entire extremity was inspected every twenty-one days. The leg was always replaced in a supportive position in the Böhler traction frame when the first cast was removed and the second was applied. The precautionary use of the traction frame is always necessary during this first change of casts, but it does not have to be continued on subsequent occasions.

Extension is maintained on the os-calcis pin for six weeks, which represents the life of the first two casts; after this, the pin is removed and the third cast is applied. The walking stirrup (Fig. 5) was usually applied to this cast in another week or ten days. The final result is illustrated in Figures 11-E and 11-F.

It might be pointed out that, if we excluded the one patient who had bilateral fracture of the os calcis, and who developed an osteomyelitis in each heel, there would be shown an average of only 9-per cent. disability for the group. This is the only case in which we have encountered any difficulties from the use of the skeletal pin traction, and we must presume that the osteomyelitis developed through the use of the pin, although the technique in this instance was no different from that employed on all of the other occasions. Figures 12-A and 12-B show the end results obtained in each heel.

When weight-bearing and walking are first commenced, the patient is specifically instructed and shown how to walk with an erect head and body, with a short, well-measured stride which should be absolutely equal with each leg. This precaution prevents the acquisition of an unnatural gait and limp which always emphasize the disability both to the patient and to his friends.

The presence of pain demands an examination of the foot. A routine examination of the injured foot is made every five days for many weeks and this allows for the institution of any needful measures for temporary assistance, such as adhesive strapping for a weakened ankle or the application of metatarsal pads for a flattening arch.

CONCLUSIONS

The closed method of reduction of fractures of the os calcis has given us an exceedingly low functional foot loss. Kessler[1] estimates that the most severe form of this fracture, which has been discussed as Type V, results in a minimum disability of 20-per cent. loss of function of the foot. There were only two instances in which even this minimum was exceeded and the average loss of function was only 12 per cent.

After healing has occurred, it is not uncommon to find that the architecture of the injured foot has been restored to an apparently normal condition, yet the patient may complain of varying degrees of pain, particularly below the malleoli. Pain on the plantar weight-bearing surface of the tuberosity is seldom as severe or as persistent as that which is found laterally, especially under the external malleolus.

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Fig. 12-A

Case 7. Lateral view of right foot nineteen months after injury.

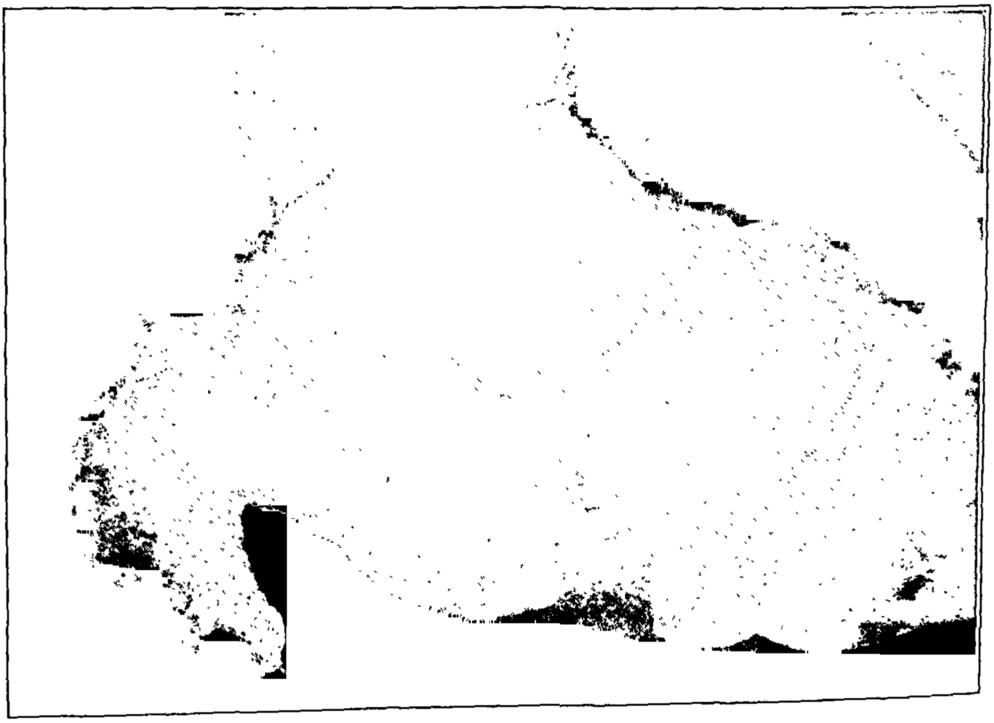

Fig. 12-B

Case 7. Lateral view of left foot nineteen months after injury.

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The loss of motion in eversion and inversion constitutes the greatest type of residual disability.

The more severe associated vertebral injuries have occurred in Type-III fractures, in which the medial condyle of the tuberosity is split off, and not in the severe comminuted cases seen in Type 5.

Skeletal traction and extension separate the subastragaloid and the cuboid articular surfaces, and this procedure also restores the architecture which will permit the resumption of the normal mechanics in the foot for weight-bearing and locomotion.

In the series of cases upon which this paper is based, the youth of the patients, the promptness of first-aid attention, and the complete facilities provided for adequate care and early reduction of these fractures undoubtedly accounted in a large measure for the low residual disabilities obtained.

Successful fracture treatment is predicated upon the interpretation of dependable and detailed roentgenograms; in this department the author has been aided by the co-operation and untiring work done by our radiographer, Mr. Ewald J. Larson, who is also responsible for the illustrations that have been used. The writer also wishes to express his appreciation to the following members of his staff—Dr. J. W. Williams, Dr. J. M. Kehoe, Dr. William T. Burton, Dr. A. G. Clark, Dr. F. M. Sutton, Dr. R. F. Jackle, and Dr. W. C. Klein—who have so ably assisted in making these results possible.

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SOME THOUGHTS ON THE PROBABLE CAUSES OF NON-UNION OF FRACTURES

BY PROF. HENRY TURNER, M.D., LENINGRAD, U.S.S.R.

Professor, Military Medical Academy;
Honorary Director of Institute for Crippled Children

The capacity of fractured bones to solidify in a few weeks and to regain their functional activity may be regarded as one of the manifestations of nature's remarkable healing power. The almost daily observation of this favorable result in fractures has somewhat diminished the interest in the intrinsic biological process which effects firm soldering of the bone fragments.

There can be no doubt that the initial quick uprising of forces which form the basis of fracture healing is stimulated and controlled by nervous factors. Acute pain, generally experienced at the site of the fracture, is the signal which calls attention to the injury and dictates the treatment, the essence of which is rest to the injured region. It may be said that the rational treatment of fractures is based on this fundamental demand for rest on the part of nature.

In considering briefly the process of consolidation of a fracture, it is permissible to compare it to what in modern technical language is known as autogenous welding,—the melting together of contiguous parts of metal and thus restoring the integrity of the disjoined parts. The process of bone union takes place in a similar manner and consists of a softening of the fragment ends and a certain degree of autolysis called "*Abbau*" by the Germans (König). This effect is produced by decalcification, the degree and limits of which vary in each case in proportion to nature's task and to the stimulant which underlies this mysterious process. The quickly formed plastic mass is then poured out between the fragments and unites them. Impregnation of this provisional callus by lime salts hardens the mass which later undergoes a process of shaping and transformation into bone tissue. Finally, no line of fracture can be seen and there remains as evidence of the injury only a slight cortical thickening which may be compared to a plumber's joint.

In contrast to the favorable course described, not infrequently the tendency to consolidation is slight and delayed precarious union, fibrous union, or pseudarthrosis may result. The abundant literature dedicated to the investigation of the factor which underlies this stubborn resistance to union is unanimous in asserting that all attempts to solve this problem have been fruitless. Briefly, the theories which have been advanced to account for non-union are: interposition of muscle or other soft tissue, inadequate reduction of the fragments and insufficient immobilization, severe traumatization of the soft parts, damage to the blood supply, and the formation of amino acids from hematomata and dead tissue. The

FIG. 1

Roentgenograms showing typical decalcification of the foot in a case of fracture of the right leg with non-union of three months' duration. The normal left foot is shown for comparison.

theory last mentioned—that a chemical agent is produced which is capable of decalcifying bone tissue—does not account for the constant component of a fracture. Many laboratory investigations have been carried out in the vain attempt to base the cause of non-union of fractures on some chemical abnormality of the blood, especially calcium and phosphorus deficiency. Recognizing the failure of finding a single factor in the production of pseudarthrosis, some authors are inclined to admit multiplicity of causes, including constitutional disturbances, physiological inertia, and other not well-defined agencies. Vitamin deficiency in diet is also included. Of the various explanations which have been suggested for the occurrence of pseudarthrosis, the influence of nervous factors is hardly mentioned. As an important element, this has not received adequate attention.

In the beginning of this paper, the author mentioned the significant fact that the sensitive nerve fibers call attention to a fracture immediately

after it has occurred. It seems reasonable to suggest that the specific acute pain which accompanies the fracture originates in the lacerated or bruised nerve fibers contained in the bone or its periosteum. We may repeat with Macewen that the solidity and hardness presented by diaphyseal bone are apt to convey the impression of immutability, whereas there are few animal tissues more prone to interstitial changes. The rôle of bone innervation in this process cannot be doubted.

The dawn of roentgenoscopy brought to light a very common pathological change in bone structure which was designated by its first observers (Sudeck, Kienböck) as acute bone atrophy. (See Figure 1.) The veil of obscurity enveloping its origin has grown thinner since the condition has been definitely linked with trauma which involves the peripheral-nerve branches. Actually representing acute bone decalcification (halisteresis), it came to be a habitual component of a clinical syndrome consisting of neuromuscular, vasomotor, secretory, trophic, and other disturbances. Well-defined morbid entities, described by the Germans as "*hartes Oedem des Handrückens*" and "*Fussgeschwulst*", presented themselves as types of complicated reflex reaction to disguised nervous irritation of traumatic origin.

A series of articles which have been published by the author and his associates since 1924 serves to prove the frequency of wide-spread decalcification, due to peripheral neuritis, in fractures and other ordinary injuries of the extremities. In some cases of Colles' fracture which followed an abnormal course, decalcification, in conjunction with the other symptoms of reflex origin, was particularly evident. With increased attention and more frequent recourse to roentgenoscopy, the author has been able to demonstrate the same rarefaction of bone in cases of injuries of the carpal or metacarpal bones as in cases of corresponding trauma to the foot. (See Figures 2, 3, and 4.)

An etiological connection between traumatic neuritis and bone atrophy has not escaped the attention of neurologists. We find the following lines on this subject in Dejerine's excellent handbook: "Finally there has been pointed out the existence of bone atrophy resulting from nerve injuries (Moty, 1892); this author has reported two cases of fracture of the leg with consequent neuritis and atrophy of the skeleton of the foot. The atrophy might develop rapidly at the end of two months; in the foot it was manifested in the tarsus and metatarsus, more rarely in the toes. These observations are interesting, but they have not been confirmed by anatomical examination of the so called atrophic bones."

The term "*ostéoporose traumatique*", recently introduced by Leriche, is used to denote the same phenomenon.

Heydemann, in 1933, described a well-defined process of acute traumatic bone atrophy, associated with fractures, as a result of circulatory disturbances. According to this author, some degree of atrophy occurs after most fractures and is demonstrable in roentgenograms if sufficient attention is paid to the peripheral portions of the bone close to the joint.

The author's repeated success in interrupting the afferent stream of irritation by sectioning or blocking a located sensitive nerve branch, and thereby stopping the obvious progress of decalcification, fully justifies his suggestions as to the etiology of its origin. From a wide clinical experience of many years, it may be asserted that the manifestations of peripheral-nerve irritation following fractures or other minor injuries of the extremities do not receive the consideration they deserve, and in a large number of cases they are entirely overlooked.

The evidence that bone tissue is susceptible to irritation originating in single nerve branches adds further support to the theory that the primary factors in the healing of fractures are trophic in nature and are the result of localized traumatic neuritis. It, therefore, seems reasonable to suppose that, if the injured area is given complete rest, the nerve irritation will promptly subside, decalcification will cease, and recalcification of newly formed tissue will lead to firm soldering of the fragments. From this point of view, it is evident that inadequate treatment plays a significant rôle in hindering bone union. In the treatment the factors to be avoided are: incomplete or technically imperfect immobilization, tight bandages, early massage or functional exercises, frequent changes of bandages for the sake of roentgenographic examination, and other manoeuvers which prevent absolute rest.

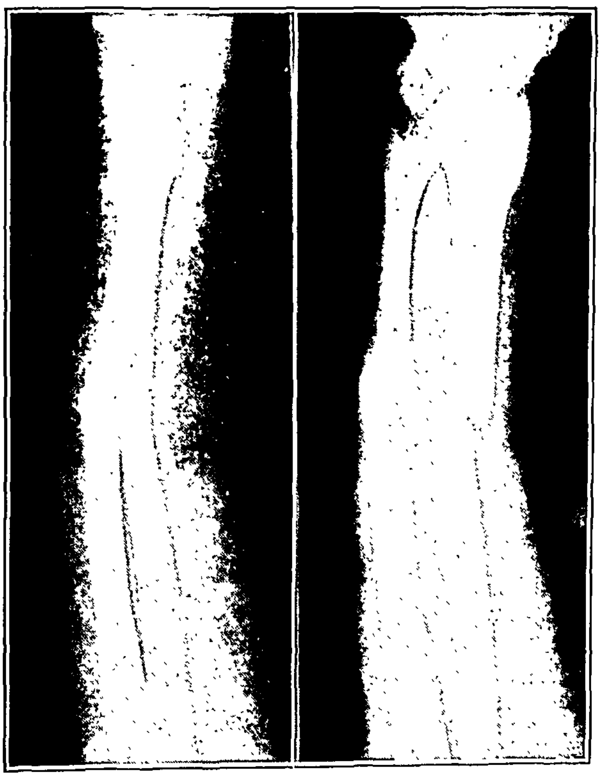

Fig. 2

M. S., aged twenty, sustained a fracture of the right forearm on April 4, 1935. Roentgenograms taken in June show non-union and marked mottled decalcification of the carpal region.

It is interesting to note that Kienböck, one of the first writers on the subject of acute bone atrophy, pointed out the frequency of this phenomenon in cases of pseudarthrosis of the forearm, but was not able to give a satisfactory explanation of its occurrence. It is an accepted fact that roentgenographic examination is generally confined to the site of fracture; if the familiar picture of non-union is observed, the examiner usually does not extend the examination. If the study of the injured bones is carried further, there are likely to be revealed wide-spread structural changes. The process of decalcification appears to be distinctly marked in the peripheral portions of the limb. The transparency of

FIG. 3

M. S. Roentgenogram showing the distal part of the extremity (right) as compared with the sound side (left). Note the conspicuous decalcification of the skeleton of the hand.

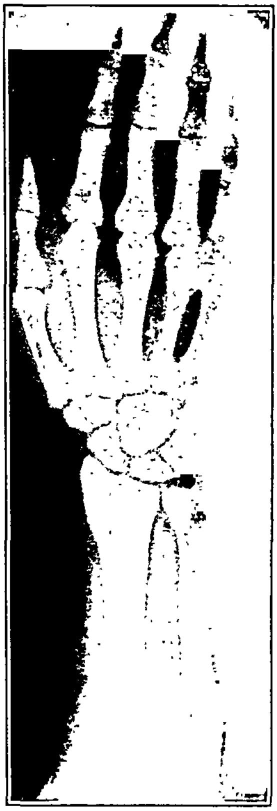

FIG. 4

M. S. Roentgenogram of right extremity, five months later than Fig. 3, showing perfect consolidation. The decalcification is less marked and the outlines of the bones of the hand are more distinct as a result of the blocking of the radial nerve by alcohol near the capitulum radii and of immobilization of the extremity in a plaster splint.

the skeleton of the hand or foot astounds the observer. A comparison with the sound extremity will help even an inexperienced eye to recognize lighter forms of rarefaction. A minute examination generally shows that the thinned bone shadow is not of uniform density and presents a mottled appearance,—the "*fleckige Atrophie*" of Sudeck. This finding permits some plausible suggestions as to the origin of bone decalcification. Recent investigations of a number of workers in biological chemistry (Sherrington, Levi, Dale, Dixon, Cannon, and others) have shown that the transmission of a nerve impulse to the muscle is performed in a physicochemical way. An excitatory substance of an acid type is released at the junction of the nerve and muscle and thereby activates the muscle. Acetylcholine is suggested as being the most probable chemical agent. It, therefore, seems safe to apply the same theory to the explanation of acute bone atrophy. In the face of rapid disappearance of lime salts from the substance of bone, it is only natural to suspect an acid solvent which arises from the nerve endings that convey distal irritation. This hypothesis may account

for the mottled character of the rarefaction seen in the roentgenogram.*

In some cases it is possible for an experienced eye to discern a cloudy area which obscures the faint outlines of the injured region. The impression is obtained that this cloudy appearance is caused by the permeation of lime salts into the soft parts in the vicinity of the fracture where they remain and assist in the process of repair.

It may be expected that biological chemistry, in the course of its rapid development, will be able to explain the significance of these clinical facts in relation to bone pathology. Physiological research will serve to determine the separate links of the chain by which nervous irritation of peripheral origin is transmitted to the substance of bone.

The practical application of knowledge already obtained is not to be underestimated. The recognition that acute trophic rarefaction frequently complicates fractures is a further step toward our understanding of the cause of occasional cases of non-union. It is easy to understand nature's difficulty in healing a fracture if the necessary cementing material is being carried away from the site of injury.

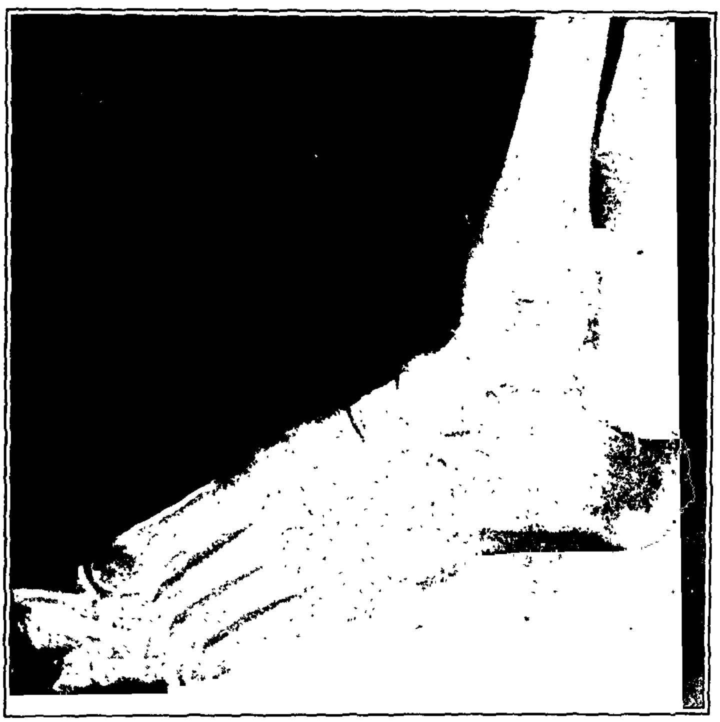

Fig. 5

Case 1. G. N. Severe neurotrophic decalcification of the skeleton of the foot, due to irritation of the saphenous branches caused by a nail driven through the metaphysis of the fractured femur.

Case 1. G. N., female, aged twenty-four, an engineer, sustained a fracture of the right femur on August 31, 1934. On admission to the hospital she was treated by extension with the aid of a nail driven through the tibial tuberosity. This treatment was continued for six weeks, during which time the patient suffered constant pain. Extension was discontinued because of suppuration about the nail, and immobilization was secured by plaster bandages.

The patient entered the Orthopaedic Clinic in the middle of November 1934. She was in a highly nervous condition and complained of pain which extended along the inner side of the injured limb from the groin down to the ankle. Fistulae on either side of the tibial tuberosity discharged freely. Digital pressure below the middle fistula occasioned great pain, which descended upward, downward, and along the limb and caused profuse sweating. Wasting of the muscles of the thigh was marked.

*A case of the development of local acidity during callus formation has been described by Häbler.

Roentgenographic examination revealed an ununited transverse fracture of the femur with lateral displacement of the fragments. On November 22 a well-fitting plaster bandage, enclosing the pelvis and the foot, was applied. The effect of complete immobilization was immediate. The pain subsided, the irritability of the patient became less, and she slept quietly. A slight percussion of the site of the fracture through a window was prescribed to stimulate the reparatory process.

On January 28, 1935, the heavy bandage was removed and slight extension with the aid of a plaster-of-Paris cuff, enclosing the semiflexed knee, was substituted. Consolidation of the fragments was already apparent. Suppuration ceased after slight curettage of the fistulae which contained small sequestra.

On February 26, 1935, a roentgenogram of the right foot showed a remarkable degree of decalcification, particularly affecting the tarsal and metatarsal bones (Fig. 5).

The patient left the Clinic on March 26, 1935, using a walking stick. There was perfect consolidation of the fragments. Physiotherapy and mechanotherapy were prescribed to increase the range of motion in the stiffened knee and to relieve the neuritis.

Summing up the foregoing clinical history, the following interpretation can be offered. The unfavorable effect of the early inadequate immobilization was enhanced by acute neuritis occasioned by the trauma and suppuration from the skeletal traction. The ramifications of the saphenous and obturator nerves on the inner side of the knee were the source of severe irritation and of the trophic factor which prevented consolidation. Complete rest by immobilization turned the healing process into its normal course. In relation to the final result which occurred after complete immobilization, the question may be raised whether or not the case should be considered as so called delayed union or non-union.

Case 2. M. F., male, aged twenty-three, a horseman, fell from his horse in November 1933 and sustained a complicated fracture of the left leg. He was admitted to the hospital within a few hours. After the limb had been immobilized for two days in a wire gutter, a nail was driven through the heel for traction. During the following sixteen days the patient suffered incessant severe pain produced by the nail. On account of suppurative osteomyelitis, the nail was removed and a plaster bandage, with windows for dressing the wound, was applied. This remained *in situ* for twenty-eight days, during which small fragments of bone were discharged from the wound. Subsequent treatment consisted of extension by adhesive plaster, followed by a plaster-of-Paris bandage which was frequently changed for inspection of the wound.

After three months, non-union was evident. Weight-bearing was then instituted according to the method of Delbet and continued for from two to three months. Circulatory disturbances produced by pressure of the Delbet plaster splints were evident as indicated by the blueness and swelling of the foot. Pain in the leg continued to be severe.

In the summer of 1934 hot-mud treatment was resorted to in the Crimea, and a molded leather splint was applied to the limb. On September 7, 1934, Leriche's sympathectomy was performed, but it had no effect on the pseudarthrosis. An osteosynthesis was then performed on November 27. Difficulties experienced in inserting the intermedullary graft led to fixation by a wire loop. The final result was negative.

The patient was admitted to the Orthopaedic Clinic on September 4, 1935, with evident symptoms of pseudarthrosis of the tibia and anterior angular curvature. Roentgenographic examination revealed distinct non-union and marked decalcification of the bones of the foot. The line of fracture was transverse and there was marked sclerosis of the ends of the fragments which were held together by a wire loop. The remains of the heterogenous bone graft were seen in the medullary cavity of the lower fragment. The fibula, which had been fractured higher than the tibia, was firmly con-

solidated. Muscular atrophy was marked. The peroneal nerve was extremely sensitive to pressure in its course behind and below the head of the fibula. The patient walked with the aid of a crutch. His chief complaint was pain in the leg.

Treatment consisted of the application of a well-fitting plaster-of-Paris bandage reaching to the knee. A few drops of 60-per-cent. alcohol were injected behind the head of the fibula to quiet the neuritic pain. Pressure on the sole of the foot when walking was allowed. Consolidation of the fragments was slow, but there was positive progress.

On November 11, because of the possibility of irritation the wire loop was extracted through a small incision under local anaesthesia. In order to stimulate the process of consolidation, the periosteum was slightly stripped off and a few holes were drilled in the fragments according to the method of Beck. This procedure quickened the callus formation. The patient left the Clinic without a cane on January 5, 1936. The pain had disappeared.

This second case is of exceptional interest. Restoration of function was obtained in a condition of common fracture of the tibia after more than two years of various forms of treatment. The principal factor in the healing—rest—remained in the background throughout the whole course of the primary treatment. A special point also deserves mention. It is well recognized that in cases of fracture of both bones of the leg the fibula usually unites more quickly and firmly than the tibia which often shows but a feeble tendency to consolidation. Various explanations have been suggested for this fact which has attracted little attention. According to Henderson and others, the early union of the fibula introduces a mechanical impediment,—the united bone acts as a pivot around which the fragments of the tibia swing. The author's repeated success in obtaining final union of the tibial fragments leads to the assumption of other theories. In spite of our somewhat limited knowledge of the innervation of bone, it may be assumed that ramifications of different nerves supply two separate bones. It is also admitted that the tibia receives more innervation and is, therefore, more sensitive to irritation.

Case 3. S. F., male, aged twenty-seven, an engineer, while riding a motorcycle on May 1, 1935, had a collision and received a complicated fracture of the middle of the lower third of the right leg. There was a contused wound on the medial side of the leg, corresponding in location to the site of the fracture. Treatment consisted of immobilization of the leg, including the knee, in plaster for three months. During this time the bandages were frequently changed. The external wound was slow in healing.

The patient was admitted to the Orthopaedic Clinic in August 1935. At that time there existed marked wasting of the muscles of the right lower leg, amounting to about three centimeters on the calf. A large reddened surface, partly cicatrized, was exposed after removal of the darkened superficial area caused by the prolonged application of silver nitrate to the wound.

Roentgenographic examination (Fig. 6) showed a transverse fracture of both bones at the same level, and non-union. The ends of the fragments were sclerosed and there was no trace of callus. There was decalcification of the distal fragments and especially of the bones of the foot. The "spotted atrophy" of the foot was particularly marked. The patient complained of severe pain in the injured area and sweating of the foot. There was marked sensitiveness to pressure over the branch of the cutaneous dorsalis intermedius on the anterior lateral surface of the ankle joint.

Treatment consisted of the application of a light plaster-of-Paris bandage, reaching from the foot to the knee. Previously, from fifteen to twenty drops of 70-per-cent. alcohol had been injected subdermally in the region of the painful nerve. Walking with

crutches was allowed. Percussion of the sole of the foot was performed daily as a stimulus.

After a period of two months, there was observed consolidation of the fragments with some callus formation. At the end of November, seven months after the accident, the patient was able to use the injured leg for support. By February 1936 the atrophy of the calf had diminished so that the part had resumed its normal appearance.

This case is regarded as a definite illustration of delayed union caused by peripheral-nerve irritation. Retarded healing of the wound, deficient callus formation, decalcification of the bones of the foot, and sensitiveness of the nerve branches all indicated trophoneurotic disturbances. Wasting of the muscles was particularly conspicuous.

CASE 4. P. M., a male, aged thirty-seven, was kicked by his horse on October 21, 1934 and sustained a complicated fracture of the right leg. Primary treatment in the hospital consisted of immobilization in plaster-of-Paris bandages. These bandages were changed frequently in order to control the position of the fragments. One month after the accident, an osteosynthesis was performed in which a heterogenous graft was used. Because of the severe pain following immobilization in plaster for two weeks, a Cramer splint was substituted for the plaster.

The patient was then transferred to another hospital. During January 1935 two

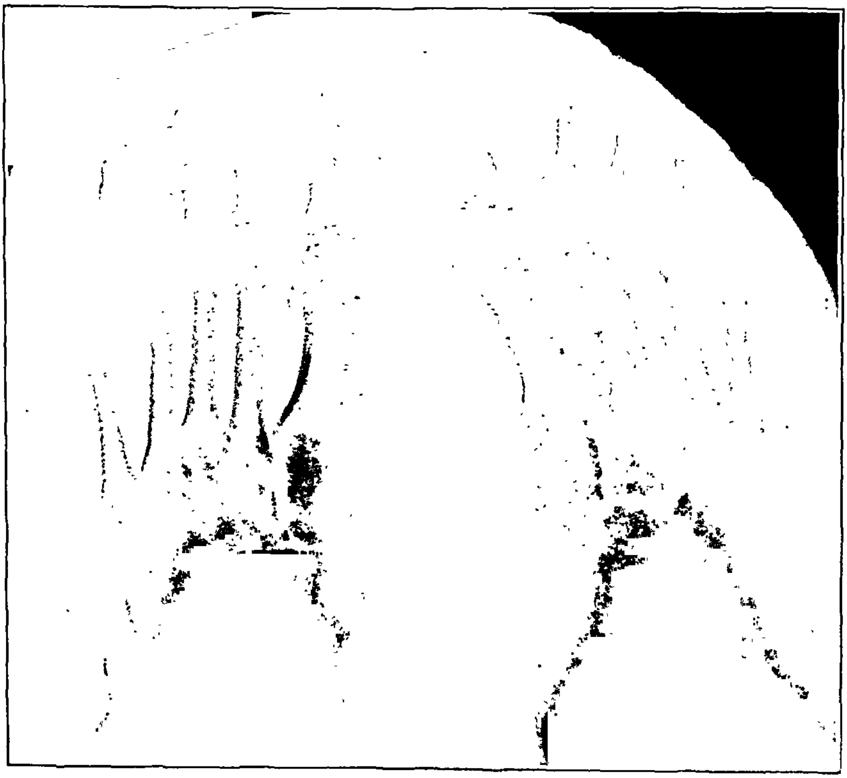

FIG. 6

Case 3. S. F. Mottled acute atrophy of the skeleton of the right foot accompanying non-union of the tibia of three months' duration.

injections of blood into the site of the fracture were given. Three intravenous injections of 10-per-cent. calcium-chloride solution were included in the succeeding treatment which was continued for some months without producing bone union. Drilling of the fragments, according to the method of Beck, was resorted to on April 28. During the following summer an attempt was made to reenforce the vitamin factors by the addition of tomatoes in large quantities to the diet. However, all of these therapeutic measures had no effect on the pseudarthrosis of the tibia.

On admission to the Orthopaedic Clinic, October 5, 1935, marked atrophy of the thigh and leg muscles was noted. There was considerable sweating of the distal portion of the extremity.

Roentgenographic examination revealed a fracture of both bones of the leg at the same level. The fragments of the fibula were firmly united by ossified callus. A crevice existed between the fragments of the tibia, traversing the indistinct remains of the intramedullary transplant. The decalcification of the tarsal and metatarsal bones and the phalanges was excessive and there was also atrophy of the bones of the leg.

Moderate mobility of the fragments in the sagittal plane could be detected by palpation. The patient complained of pain in the inner side of the limb from the knee to the ankle. Examination showed hyperaesthesia and painful sensibility of the subcutaneous nerve fibers on the same side. Weight-bearing was possible only with the aid of crutches.

The clinical findings indicated that the stubborn resistance of the tibia to union was definitely associated with neuritis which may have had its origin in the severe bruising of the soft parts at the time of the injury. Treatment was directed toward quieting the nerve irritation. Subcutaneous injections of small quantities of alcohol were made on the inner side of the leg near the sensitive nerve branches. The beneficial effect of the blocking was marked. The patient urged repetition of the injection in spite of the temporary pain produced. Other sensitive nerve branches were given the same treatment at different intervals. The patient was allowed to walk without crutches. A protective plaster splint was applied to the leg. Serial roentgenograms showed gradual fusion of the fragments of the tibia and osseous solidification of the crevice.

On January 5, 1936, after fourteen months of treatment, the patient returned to service with a useful leg.

CASE 5. K. M. Y., a male, aged thirty, was run over by an automobile on September 27, 1934, and sustained a fracture of the left leg. He entered a hospital immediately, where treatment consisted of plaster-of-Paris bandages, frequently changed. Massage was begun one month after the accident. There was incessant severe pain. The patient entered the Orthopaedic Clinic on December 19, 1934, and a roentgenogram (Fig. 7-A), taken immediately, showed feeble attempts of the bone to consolidate during the three months of treatment. Five months after the accident, there was distinct decalcification of the skeleton of the foot on the injured side (Fig. 7-B). Treatment consisted of a well-fitting plaster-of-Paris bandage, including the knee, and light weight-bearing on the sole. A roentgenogram (Fig. 7-C), taken on March 3, 1935, after three months of firm fixation, showed abundant callus formation.

These clinical observations illustrate a phenomenon to which the author's attention has been increasingly attracted during these last years. No factor in the occurrence of these cases could account for the evident delay in bone consolidation which lasted from some months to more than two years, and the final results obtained in them contradict the theories usually advanced to explain the underlying cause, such as interposition or deficiency of bone tissue, etc. It would appear that interference and the frequent change of methods of treatment hinder nature's healing process in some cases. The essential obstacle to healing may be regarded

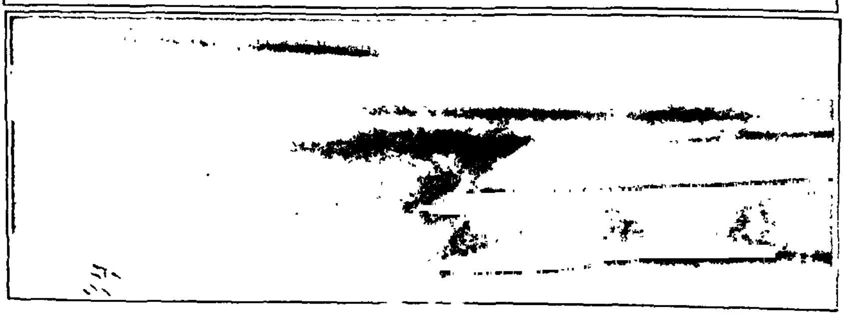

Fig. 7-A

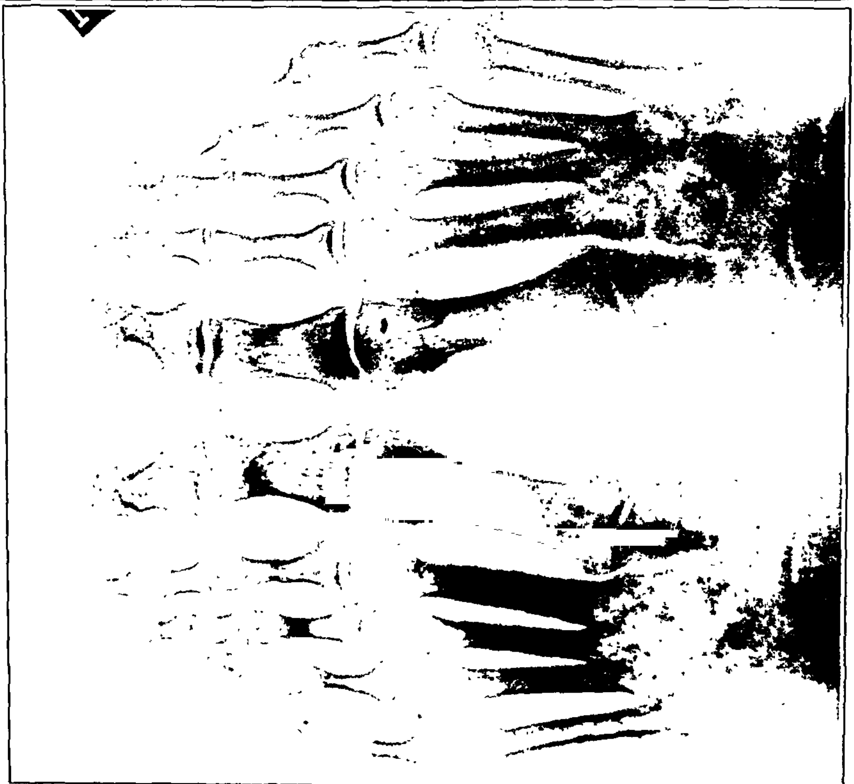

Fig. 7-B

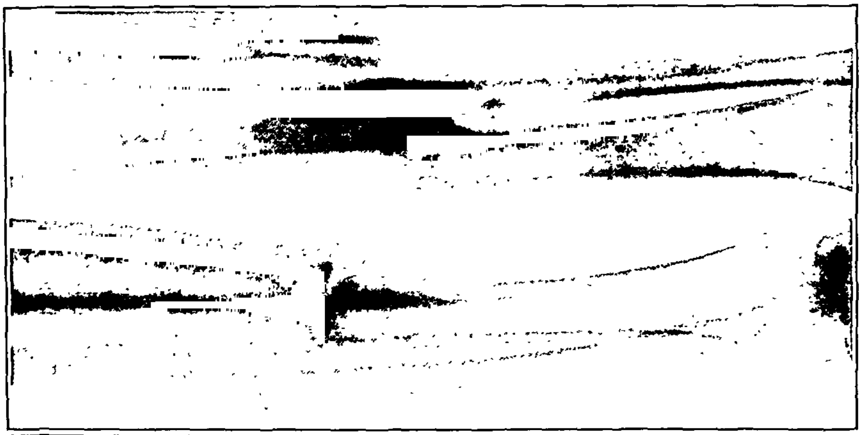

Fig. 7-C

Fig. 7-A: Case 5. K. M. Y. Roentgenogram, taken on December 19, 1934, three months after injury.
Fig. 7-B: Roentgenogram, taken five months after injury, showing distinct decalcification.
Fig. 7-C: Roentgenogram, taken on March 3, 1935, showing abundant callus formation.

in the light of a protraction and extension of a biological process which primarily stimulates bone union. The author ventures to suggest that some elements in the usual methods of treatment may create unnecessary sources of nerve irritation.

SUMMARY

Acute bone decalcification is an essential part of a biological process which, in cases of fracture, leads to bone union. This temporary rarefaction is reflex in nature and proceeds from traumatic irritation of the nerve branches which supply the bone and the periosteum. When the irritation subsides, this process is brought to a standstill and is replaced by deposition of lime salts in the newly formed soft callus and the decalcified ends of the fragments. A soldering of the fragments is thus obtained. In some cases, this irritation of the nerve branches continues for a long period and prevents nature from carrying out the normal healing process. Local deficiency of lime salts causes delay in bone union and may even prevent consolidation.

The etiology of this condition may be ascribed to unusual involvement of the sensitive nerve branches, due to trauma, or to methods of treatment which tend to maintain the irritation of the afferent nerve conductors. Fractures of the forearm and leg are especially prone to non-union because of their profuse and diversified innervation. In cases of fracture of the forearm, disregard of the rules of reduction and immobilization is an important factor in the production of pseudarthrosis. The sensitive nerve branches which may be chiefly accused of sustaining irritation and favoring non-union appear to originate in the upper part of the limb from the radial-nerve and ulnar-nerve cables. In the lower limb the corresponding sources are the obturator, saphenous, and peroneal nerves. A special branch of the peroneal nerve, located on the dorsum of the foot and known as the cutaneus dorsalis intermedius, has been found by the author to be especially prone to neuritis of a degree capable of producing marked decalcification. Another form of neuritis, associated with the treatment of fractures, arises from the modern free use of nail extension. Indiscriminate piercing of the bone in such profusely innervated regions as the inner side of the knee and the calcaneum frequently gives rise to stubborn neuritis with consequent wide-spread decalcification.

In the clinical examination of slowly healing fractures more attention should be paid to the possible involvement of the peripheral-nerve branches. Roentgenographic examination should not be limited to the immediate site of injury. Decalcification which extends toward the most distal part of the limb should be regarded as positive proof of existing traumatic neuritis.

Acute bone atrophy plays a conspicuous rôle in the general pathology of osseous tissue. The aid of physiology and physiological chemistry is needed in solving the problem of this complex process.

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OLD DISLOCATIONS OF THE SHOULDER *

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During the past twenty years much has been accomplished in the cure of recurrent dislocation of the shoulder, but little has been done to improve the treatment of acute or old dislocations or fracture-dislocations. Nothing of great interest has been added to the literature since Dollinger's masterpiece in 1911, in which he emphasized the importance of the division of the subscapularis and very minutely described the existing pathological process.

In this paper, only those cases in which reasonable and well-advised manipulative procedure has failed will be considered as cases of old or irreducible dislocation. The cases which are reported were so treated before open reduction was advised. Fracture-dislocations in which union had occurred at the site of fracture come within this group and were treated as dislocations. Acute fracture-dislocations will not be considered.

The vast majority of dislocations of the shoulder are of the anterior type and may be divided into three groups: first, intracoracoid,—cases in which the head of the bone becomes fixed between the glenoid fossa and the coracoid process; second, subcoracoid,—cases in which the head becomes fixed under the coracoid; and third, subclavicular,—cases in which the head passes beyond the coracoid. This fine differentiation has no particular bearing on the indications for arthrotomy or the operative manipulations. The posterior and subglenoid dislocation is so uncommon that no special consideration of it will be given here.

In the treatment of an old dislocation of the shoulder, there are two points to be considered: first, ultimate function; and, second, how much can be accomplished by conservative treatment,—physiotherapy. Painless adaptation and fair function in some instances have been reported. Dessaint and many of the French school have reported such cases. A patient of advanced years should not be considered as a candidate for open reduction, as some improvement in function can be obtained by physiotherapy. However, by and large, old dislocations are painful and the discomfort is not lessened by time or by physiotherapy. Many cases unsuccessfully treated by this method have also been reported. Delbet, after an extensive study, very tersely summarized his conclusions in these words: "Arthrotomy is the means, reduction is the goal, and resection is the expedient."

Because of the pain associated with an old dislocation of the shoulder, operative interference is indicated. The end results of such an operation are most satisfactory from the patient's point of view. Even though there is a limited range of motion, a shoulder in which the dislocation has

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 7, 1935.

been reduced by arthrotomy is painless and much more useful than it would have been if a resection had been done, especially if the shoulder were damaged to the extent usually found in an old dislocation.

The operation has always been considered difficult, but there are two or three points which, if recognized, lessen the difficulties in accomplishing the desired reposition of the humerus into the glenoid fossa. The surgeon should use the incision with which he is most familiar, but most surgeons prefer the anterior incision which opens the operative field between the margin of the deltoid and the pectoral muscles. In some cases, the fibers of the deltoid muscle have been separated. In the author's opinion, this allows the glenoid fossa to be cleared out more easily than does the extreme anterior incision. If one is handicapped by lack of sufficient space with the use of the straight anterior incision, then the incision may be continued anteriorly along the margin of the clavicle. By this means, the pectoral fibers are freed and more exposure toward the midline is obtained. The incision may also be extended posteriorly along the margin of the deltoid and its attachment to the acromion. Through this exposure, the pathology is at once apparent. The supraspinatus, infraspinatus, and teres minor, and the capsule are drawn across the glenoid fossa, obliterating the normal space. The muscles and tendons are fibrosed in proportion to the amount of trauma sustained at the time of injury and the length of time which has elapsed since the dislocation. In a great many cases, the tuberosities, with their muscle attachments, are also torn free.

It seems to the author that one of the most important steps in the operation is the clearing of the glenoid fossa, so that after the subscapularis has been cut, which allows external rotation and delivery of the head, there is sufficient space in or about the glenoid to enable reposition to be made.

Cubbins has expressed the opinion that the biceps tendon is responsible for the difficulty in reducing a dislocation of the shoulder. In only two cases in the writer's experience has the biceps tendon interfered with reduction. The biceps is often very badly damaged, particularly in those cases where there was a fracture of the tuberosity at the time of the dislocation. In many instances, the biceps is severed and the distal end of the tendon will be found adherent to the humerus in the region of the fracture.

The author believes that one of the most serious obstacles in the way of obtaining a stable, movable shoulder is the manufacturing of an anterior portion of the capsule. This portion is usually so badly destroyed by the original dislocation and subsequent atrophy that very little of it can be reclaimed, and, at the outset of exploration, every effort should be made to conserve, in so far as possible, the structures about the anterior portion of the shoulder joint, so that the anterior capsule may be reconstructed. It is quite possible at times to detach the supraspinatus and to transplant it into a more forward position. On many occasions, the author has been

obliged to resort to plastic operations, using fascia lata. In one or two cases, the long head of the biceps was implanted into the head of the humerus, and, in one case, the coracobrachialis and the long head of the biceps were transferred to a short portion of the anterior capsule. In other words, there is no orthodox method for the reconstruction of the ligaments about the shoulder and one has to resort to any means possible in order to obtain this. Of course, it is quite often impossible to subject an elderly patient to a long period of anaesthesia and, therefore, a new anterior portion of the capsule cannot be manufactured. Such a case invariably results in a slight anterior luxation of the shoulder when the arm is abducted. However, even with this apparent deviation from the ideal, the result of this operation is a painless shoulder with a fair range of abduction.

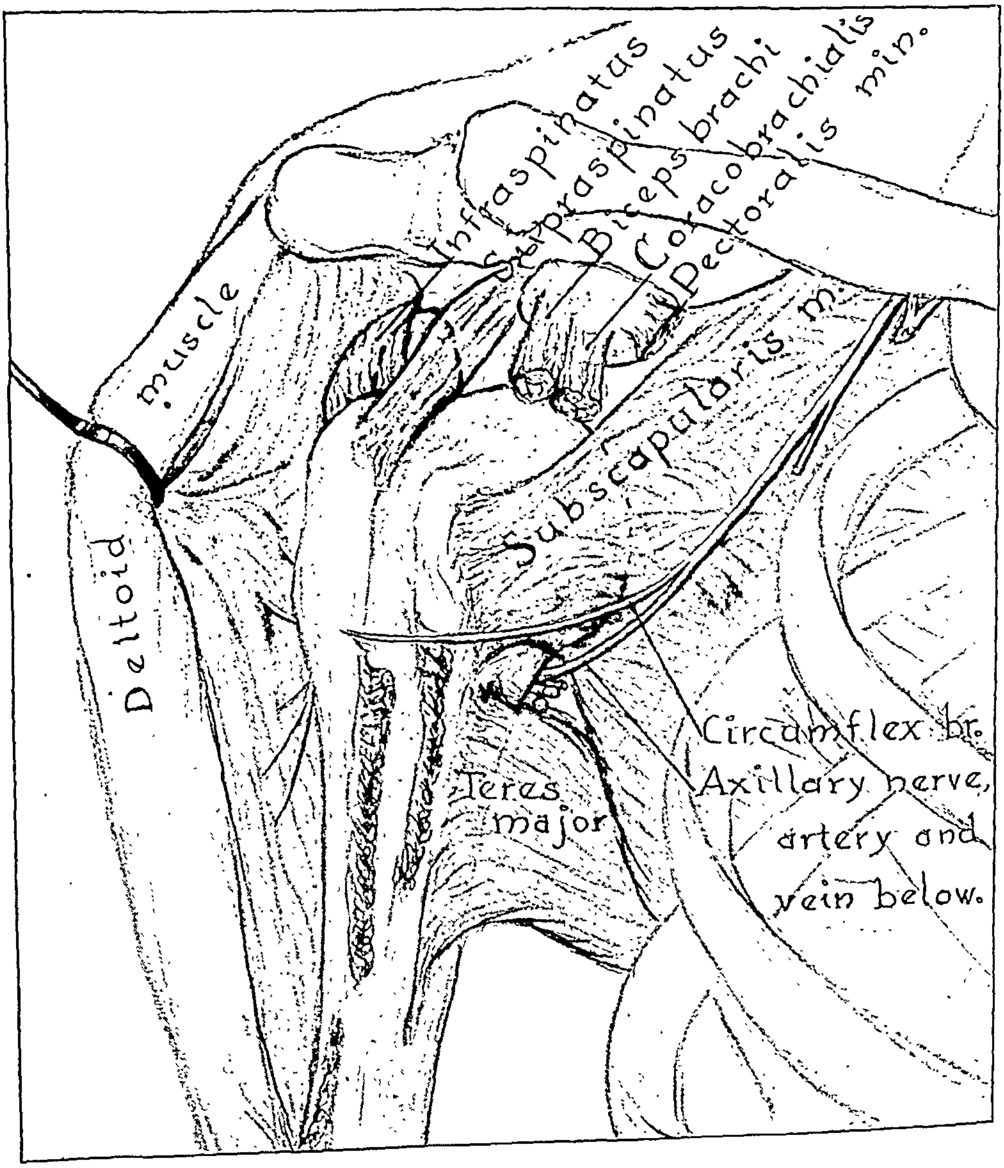

FIG. 1
Showing position of circumflex and axillary nerves.

Too much stress cannot be placed on the importance of the cutting of the subscapularis. Many times it has been found necessary to divide the tendon of the pectoral muscle before the head of the humerus could be delivered from its lodging place about the coracoid process.

The writer has found that the most satisfactory position in which to maintain the head of the humerus near its normal position is that of the so called position of salute,—the arm abducted to about 80 degrees and the humerus looking forward. This produces a direct posterior pressure and forces the head backward, relaxing the tissues about the anterior portion of the shoulder joint. This position is maintained for a period of between four and six weeks and is followed by physiotherapy.

What is to be expected as an end result of an old and irreducible dislocation of the shoulder after such a mutilating operation? In most cases, the axillary nerve is injured by the original dislocation and the malposition of the head of the humerus over a period of months, and not infrequently it is probably injured during the time of operation, so that, in a great many old dislocations, a weakness, but not a complete paralysis, of the deltoid is the end result, which impairs the movement of the shoulder in abduction.

If one analyzes the results obtained, it will be found that better function can be expected in the early cases. There is a much better chance of securing normal function in a shoulder in which reduction was obtained within the first month or six weeks after the injury than in a shoulder in which reduction was accomplished six months after the injury. Some very unusual cases have been reported in which supposedly normal function has been obtained in old dislocations of the shoulder, but the author's experience has been that the sooner the operation is performed the better the function which is obtained. The writer believes that if 45 degrees of voluntary abduction is secured in an old dislocation of the shoulder, in which the head of the humerus has been in malposition over a period of six months, the result is very satisfactory.

The points which have been mentioned are based on the author's experience with approximately twenty cases of old irreducible dislocation of the shoulder. It has been possible to collect satisfactory records of only fourteen cases, as a number of these patients were operated upon in small rural hospitals where the records are incomplete or the case histories have been lost and accurate notes are not obtainable.

CASE REPORTS

Case 1. M. S., a female, aged thirty-seven years, was admitted on December 12, 1922. Seven months prior to admission, the patient had sustained a fracture-dislocation of the right shoulder and a fracture of both bones of the forearm. The fracture of the upper third of the humerus had been allowed to heal, but the dislocation of the shoulder had not been reduced. Neurological examination confirmed the clinical opinion of a paralysis of the deltoid, probably the result of an injury to the axillary nerve.

An arthrotomy of the shoulder was performed through the anterior incision between the inner margins of the deltoid and pectoral muscles. The glenoid fossa was cleared of

a mass of fibrous tissue; the subscapularis was divided; and the head of the humerus was dislodged from beneath the subcoracoid process and delivered into the glenoid fossa. The biceps tendon was very markedly frayed. Only a small portion of the anterior part of the capsule could be reclaimed, and the tendon of the coracobrachialis and the biceps was fastened to the short portion of the anterior part of the capsule, thus reenforcing the capsule at this point. The arm was placed in the salute position of abduction, the head of the humerus looking forward.

In view of the fact that the patient apparently had a complete paralysis of the deltoid, the head of the humerus was partly scarified and the arm was maintained in a position of abduction for a period of two months, as a fibrous ankylosis was considered desirable.

The patient made an uneventful recovery. Although function in the deltoid has not been recovered, the patient has an active, useful arm with 60 degrees of abduction, but no free motion in the shoulder joint.

Case 2. G. T., a male, aged forty years, was admitted on July 1, 1925. The patient had sustained a dislocation of the left shoulder five weeks previously. An attempt at reduction under anaesthesia was unsuccessful.

At operation, through the anterior incision, the shoulder was explored. The glenoid fossa was cleared of fibrous tissue and the tendons of the supraspinatus and infraspinatus muscles were severed. The head of the humerus was palpated beneath the coracoid process. Several exostoses were noted about the margin of the head and were removed, after which the subscapularis was divided. By external rotation, the head of the humerus could be delivered, but was obstructed by the biceps tendon which was then divided. The head of the humerus was replaced in the glenoid fossa and the anterior capsule was repaired, utilizing the tendon of the biceps as a reenforcement of the anterior part of the shoulder joint. The arm was placed in a plaster-of-Paris dressing in abduction of about 45 degrees and slightly forward.

The patient was examined a few weeks after operation, but the writer has been unable to communicate with him since that time and the end result cannot be reported.

Case 3. Mrs. J. S., aged fifty-six years, was admitted on August 19, 1927. Three weeks prior to admission, the patient had fallen and had injured the right shoulder. Both physical and roentgenographic examinations showed a fracture-dislocation of the right shoulder.

The author was of the opinion that sufficient union had occurred at the site of fracture to justify an attempt at reduction at this time. Under anaesthesia, manipulation was done without success. An arthrotomy was then performed and, with very little difficulty, the head of the humerus was dislodged from beneath the subcoracoid process. The fragments, however, became disengaged at the line of fracture and were wired into position after reduction.

The patient made an uneventful recovery. One year after operation, she had 80 degrees of abduction, with no evidence of any paralysis of the deltoid.

Case 4. A. P., a male, aged twenty-five years, was admitted on May 26, 1929. Three years previously, the patient had dislocated both shoulders during a convulsive seizure associated with a meningitis. No attempt at reduction had been made.

Physical examination showed a rather unusual atrophy of the supraspinatus and infraspinatus muscles of both shoulders with a distinct depression and flattening posteriorly. There was very little motion between the head of the humerus and the coracoid process, but the scapulae had compensated for this lack, so that there was external rotation, but very little internal rotation.

The author informed the patient that he was not sure he could accomplish a reduction at this late date. The arm was put in traction over a period of several days in order to stretch the muscles about the shoulder joint.

On June 13, 1929, the shoulder was explored through the anterior incision. It was

not possible to identify either the supraspinatus or the infraspinatus muscle. The glenoid was cleared of a mass of fibrous tissue. The cartilaginous surface of the glenoid was considerably damaged. The subscapularis tendon was divided and, with great difficulty, the head of the humerus was dislodged from its resting place beneath the coracoid process and placed in the proximity of the glenoid fossa. A complete reduction could not be obtained. An attempt was made to repair the anterior capsule, but there was very little available tissue. The arm was placed in a few degrees of abduction and slightly forward.

Five years after operation, there was no free motion in the shoulder joint, but there was about 30 degrees of abduction due to scapular movement. When compared with that of the opposite shoulder, function had not been improved.

The author was very doubtful before the operation that he could improve the condition of the shoulders in this case, but the patient and his family were very anxious to see if something could be done. The case is reported as a failure as the patient does not feel that he has been benefited in any way. This is the only case of this type reported in this series.

Case 5. A. M., a male, aged sixty-four years, was admitted in March 1931. Seventeen months previously, the patient had dislocated the right shoulder. On admission, he complained of loss of function of the arm, and of discomfort.

Examination revealed a subcoracoid dislocation of the shoulder, with marked restriction of motion. Attempted manipulative reduction was unsuccessful.

An open operation was then performed, in which the anterior deltoid incision was used. The head of the humerus was found in the subcoracoid position. The capsule was not identified. The glenoid fossa was found to be filled with scar tissue which was carefully removed. Attempts at moving the head of the humerus at this stage, after the division of the subscapularis, were not successful. On further search, an exostosis was found in the region of the greater tuberosity, which seemed to prevent reduction. This exostosis was removed and the head was levered into the glenoid. The arm was placed in a plaster Velpeau bandage.

The patient was seen four weeks after operation. He then disappeared and a final check-up cannot be obtained.

Case 6. M. H., a female, aged sixty years, was admitted on April 29, 1931. Seven months prior to admission she had fallen and had dislocated the right shoulder.

Examination revealed an old subcoracoid dislocation of the shoulder. An attempted closed reduction under anaesthesia was unsuccessful.

At operation, April 30, 1931, there was present the usual condition of obliteration of the glenoid fossa by a mass of fibrous tissue and the atrophied tendons of the supraspinatus and infraspinatus muscles. The glenoid was cleared of fibrous tissue and as much of this tissue as possible was reclaimed. The head of the humerus was identified beneath the coracoid process; the subscapularis was divided; and, with very little difficulty, the head of the humerus was replaced in the glenoid fossa. The arm was fixed in abduction.

Four years later, examination showed 70 degrees of free motion in abduction, elevation of the arm to a right angle, and a slight weakness of the deltoid. The shoulder is painless, and function is satisfactory.

Case 7. K. M., a female, aged sixty years, was admitted on May 13, 1932. Two months prior to admission, the patient had sustained a dislocation of the left shoulder. Attempts at reduction had been unsuccessful.

Examination showed a typical subcoracoid dislocation of the shoulder.

Exploration of the shoulder, through the anterior incision, disclosed that the glenoid fossa was filled with old blood clots and semifibrous tissue. The supraspinatus and

infrapinatus muscles were identified and freed from their attachments about the tuberosities. The head of the humerus was then identified in a subclavicular position, having passed beyond the coracoid process. With a great deal of difficulty, the humerus was freed from this position; the subscapularis was divided; and reduction was obtained. The patient was very shocked by the operation and time did not permit the manufacturing of an anterior portion of the capsule of the joint.

Three years later, examination showed that the patient had about 40 degrees of voluntary abduction, but the arm could be passively abducted to 90 degrees.

The patient is well satisfied with the end result, although there is considerable relaxation of the anterior part of the shoulder joint.

Case 8. T. H., a female, aged fifty-nine years, was admitted on April 28, 1933, suffering from an old dislocation of the shoulder of five months' duration. Reduction by manipulation had been attempted without success. The patient complained of pain and discomfort, and an inability to use the arm.

An operation was performed on April 29, 1933, through the usual anterior incision, by the resident surgeon who stated that he had succeeded in getting the head of the humerus in or about the glenoid fossa. Roentgenograms, made one week later, however, showed the shoulder to be dislocated.

The author expressed the opinion that the head had not been replaced in the glenoid fossa, and an exploratory operation was done on May 23, 1933, which confirmed this opinion. The glenoid fossa was cleared of a fibrous mass and the head of the humerus was replaced.

Examination, about two years after the operation, showed only about 40 degrees of voluntary abduction, although the shoulder could be passively abducted to about 90 degrees. There was quite a marked limitation of internal and external rotation and a moderate relaxation of the anterior portion of the capsule.

The patient has a useful, painless arm and is very well satisfied with the result.

Case 9. E. B. F., a male, aged sixty-two years, was admitted on July 24, 1933. Six weeks prior to admission, the patient had sustained a subcoracoid dislocation of the shoulder, which had not been recognized. Manipulative reduction was attempted, without success. The arm was then placed in continuous traction for a period of forty-eight hours and a second attempt at reduction was made, also without success.

On August 1, 1933, an open operation was performed through the usual anterior incision, and the head of the humerus was located beneath the coracoid process. The glenoid fossa was cleared of fibrous material and the subscapularis was divided. An attempt was made to deliver the head of the humerus, and, during this procedure, the humerus was fractured just below the tuberosity. This in no way interfered with the reduction. The patient's condition was such that it was impossible to reenforce the anterior part of the capsule of the joint. The arm was placed in a plaster dressing in the salute position.

Examination, eighteen months after operation, showed that the patient had a very marked weakness of the deltoid. The head of the humerus was slightly forward and downward.

There is a marked weakness of the deltoid with only about 30 degrees of voluntary abduction. The shoulder is painless and the patient states that he is very well satisfied with the end result.

Case 10. J. P., a male, aged fifty-eight years, was admitted on October 29, 1933. Six months prior to admission, the patient had been operated upon by Dr. Dandy for removal of a brain tumor. Neurological signs had persisted after his return home and, during an attack, he had fallen and had dislocated the right shoulder.

An attempt at reduction was unsuccessful. The patient presented the typical picture of a posterior dislocation of the shoulder. Under anaesthesia, the shoulder could be reduced, but would immediately slip back into the posterior position. Exploration

FIG. 2

Case 12. B. G., aged fifty years. Subcoracoid dislocation of shoulder with fracture of tuberosities of four weeks' duration.

disclosed that the biceps tendon had been torn free from the bicipital groove and was acting as an obstacle in the reduction of the shoulder. The tendon was divided and the Nicolai type of operation for fixation of the head was done.

A few days after the operation the patient became totally disoriented and he died eight

FIG. 3

Case 12. B. G. Three weeks after reduction.

FIG. 4

Case 12. B. G. Fourteen months after operation. Voluntary abduction of 45 degrees. Painless shoulder. Axillary nerve injured in original dislocation.

days after the operation. It was felt by all concerned that the operative procedure had nothing to do with the patient's death.

This case is one of the few instances in which the long head of the biceps acts as a factor in preventing the reduction of a dislocation of the shoulder.

CASE 11. J. T. D., a male, aged fifty years, was admitted on July 8, 1934, with a typical subcoracoid dislocation of the left shoulder. On July 13, 1934, the author attempted manipulative reduction under anaesthesia, which was unsuccessful.

On July 20, 1934, approximately one month after the injury, an open reduction of the shoulder was done. Fascial sutures were used in order to repair the anterior part of the capsule. The patient developed an infection.

Examination, made on February 13, 1935, showed a relaxation of the anterior part of the capsule. The deltoid was strong, and there was voluntary abduction of 60 degrees. The patient stated that motion was gradually increasing.

The patient now has a shoulder that functions well.

This is a case of a relaxation of the anterior part of the capsule following unsuccessful repair and slight infection.

CASE 12. B. G., a female, aged fifty years, was admitted on February 12, 1934. One month prior to admission, she had fallen and had dislocated the left shoulder.

Manipulative reduction was unsuccessful and, on February 23, 1934, an arthrotomy was performed through an anterior incision. The greater tuberosity, with its muscle attachments, was found to be free. The glenoid fossa was cleared of a fibrous-tissue mass and the shoulder was reduced without division of the subscapularis. The greater tuber-

FIG. 5

Case 13. M. S., aged forty-one years. Subcoracoid dislocation of shoulder of three months' duration, following manipulation for adhesions of shoulder.

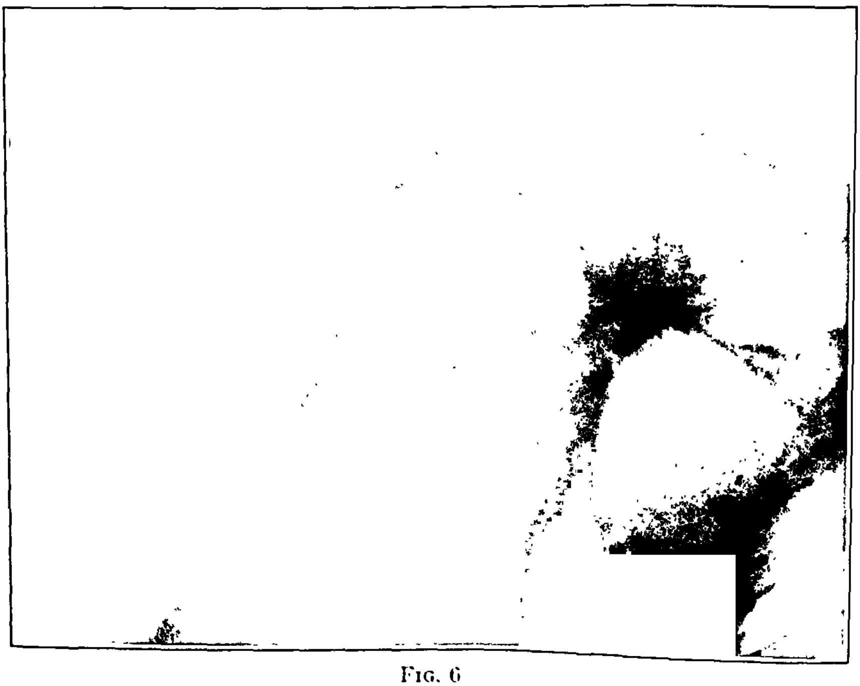

FIG. 6

Case 13. M. S. One year after operation. Weakness of deltoid gradually improving. Voluntary abduction of 50 degrees. Passive abduction to 80 degrees.

FIG. 7

Case 14. A. A., aged sixty-two years. Subcoracoid dislocation of shoulder with fracture of the tuberosities. Seventeen months after injury.

FIG. 8

Case 14. A. A. Two months after reduction. Patient has voluntary abduction of 40 degrees.

osity was fixed in place with a small nail. The arm was placed in a slightly forward and abducted position.

The patient made an uneventful recovery. Examination, fourteen months after the operation, showed voluntary abduction of 45 degrees with passive abduction of 80 degrees. There was good power in the anterior and posterior portions of the deltoid, but the midsection of the deltoid seemed weakened.

The patient states that she has a painless and useful arm and is very well satisfied with the end result.

Case 13. M. S., a male, aged forty-one years, was admitted on May 13, 1934. Eight months previously, he had injured the right shoulder. He continued to have discomfort for several weeks. About three months before he was seen by the author, the patient had been given a general anaesthetic and the shoulder had been manipulated for the release of adhesions. Manipulation did not improve the condition, — the arm remained persistently painful with marked loss of function.

On admission, physical examination showed considerable atrophy in the region of the deltoid. Roentgenographic examination revealed a typical subglenoid dislocation of the humerus.

On May 14, 1934, an operation was performed through the anterior incision. The glenoid fossa was cleared and the supraspinatus muscle was detached from the tuberosity. The subscapularis was divided, and reduction was accomplished. The arm was placed in a Velpeau bandage in a few degrees of abduction.

A recent examination showed a moderate weakness of the deltoid with about 65 or 70 degrees of voluntary abduction. The shoulder is painless and function is very satisfactory. The condition is gradually improving.

The author assumes that the dislocation occurred at the time of manipulation and not at the time of original injury, eight months before the date of operation. Therefore, this case is listed as a dislocation of three months' duration.

Case 14. A. A., a male, aged sixty-two years, was admitted on March 27, 1935. Seventeen months previously, he had fallen and had injured the right shoulder. He consulted a "bone-setter" who manipulated the arm.

Physical examination showed a typical subcoracoid dislocation, with a flattening of the shoulder joint, but with a good functioning deltoid. Roentgenographic examination disclosed a very marked deformity anterior to the greater tuberosity, with excess bone formation at this point.

At operation, through the anterior incision, the thickened area about the greater tuberosity was partially removed, and the tendons of the supraspinatus and infraspinatus were freed. A rather thick, firm mass of fibrous tissue was removed from the glenoid fossa. The head of the humerus was identified beneath the coracoid process. The subscapularis and the tendons of the pectoral muscle were divided before the head could be rotated from its resting place. Reduction was obtained and a surprisingly good anterior portion of the capsule was reconstructed with the tendons of the supraspinatus and the remaining portion of the capsule. The arm was placed in a Velpeau bandage in the salute position.

Six weeks after operation there was good power in the deltoid and about 40 degrees of voluntary abduction. The shoulder is painless and the patient seems very well pleased with the result.

SUMMARY

In cases of old dislocation of the shoulder, operation is indicated for restoration of function and relief of discomfort.

Operation is advised in all early cases. In the older cases, in which

the shoulder has been dislocated for several months and there is painless adaptation with 50 degrees of free movement, operation is not advisable. Experience has shown that the end result in these cases is seldom perfect function of the shoulder with a free range of motion. In most instances the free movement obtained is in proportion to the duration of the dislocation. The early cases are much more successful.

Weakness of the deltoid is present in a large percentage of cases following operation. This may be due either to the original injury or to operation, as the nerve supply to the deltoid may be easily damaged by the division of the subscapularis muscle.

The first step in the operation, in the author's opinion, is the clearance of the glenoid fossa and the division of the subscapularis muscle, but *the most difficult step is the reconstruction of the anterior portion of the capsule.* This may be accomplished by utilizing the long head of the biceps, as described by Nicolai in his treatment for recurrent dislocation of the shoulder, or by reenforcing the anterior part of the capsule with fascial sutures. In one or two instances the writer has transferred the tendon of the coracobrachialis and the long head of the biceps and attached them to the short superior portion of the capsule, thus reenforcing the anterior part of the joint. While operation for an old dislocation of the shoulder may not result in 100 per cent. function, it is much more satisfactory than a resection of the head of the humerus for the same condition.

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RECONSTRUCTION OF THE DIGITAL TENDON SHEATH

A Contribution to the Physiological Method of Repair of Damaged Finger Tendons *

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Through the researches of Biesalski, Henze, and Mayer it has been proved that adhesions to transplanted tendons can be prevented most effectively by avoiding trauma to the gliding mechanism of the tendon. This mechanism consists partly of the sheath, partly of the paratenon (the loose gliding tissue which intervenes between the tendon and the rigid fascia), and finally of the smooth, gliding cells on the surface of the tendon. Damage to any portion of the gliding mechanism is likely to result in the formation of an adhesion which prevents the motion of the tendon. In operating on paralyzed limbs where normal tendon sheaths are available, it is possible in almost all instances to minimize the formation of postoperative adhesions by running the transplanted tendon through the sheath of the paralyzed tendon. If the operator exercises a reasonable degree of care and does not damage the delicate, gliding cells on the surface of the tendon or on the corresponding smooth inner wall of the tendon sheath, a free, gliding motion comparable with the normal usually results. In a check-up of over 400 tendon transplantations done for paralytic conditions, the authors found approximately 90 per cent. of good or excellent results.

In dealing with traumata to the finger tendons, however, conditions are quite different and the results of tendon transplantations have been extremely disappointing. The reason for this is evident when one considers the pathological changes which occur after a division of the flexor tendons of the fingers. Even if no infection occurs, adhesions form which bind the distal stumps of the flexor digitorum sublimis and the flexor digitorum profundus tendons to one another and to the inner wall of the tendon sheath (Fig. 1).

These adhesions extend from the point of division of the tendons down to the distal end of the digital theca. They destroy the smooth cells on the surface of the tendon and the sheath. The proximal tendon stumps retract, leaving a gap of several inches between them and the distal stumps. Like the distal stumps, they become bound to one another by adhesions, but these rarely extend proximally for more than one inch.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 14, 1936.

The gap between the tendon ends is filled with scar tissue which replaces the tendon sheath. It is obvious that the normal gliding mechanism of the tendon has been completely destroyed and that, consequently, the conditions for reestablishing free gliding of a transplanted tendon are so unfavorable that only in exceptional instances can an implanted tendon perform its normal function.

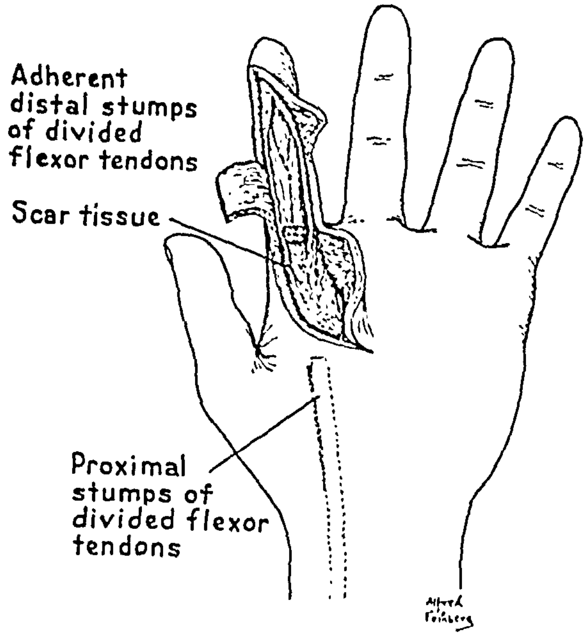

Fig. 1

Pathological conditions found when the flexors of the index finger have been severed near the metacarpophalangeal joint. Note the scar tissue binding the tendons to one another, destroying the tendon sheath, and filling the gap between the tendon stumps.

If a mild infection has occurred, the adhesions are denser, and the degree of damage increases with the severity of the infection.

Despite the cases reported by Bunnell, Koch, Cleveland, and a few others, the percentage of satisfactory results has been so low that experienced surgeons hesitate to undertake the operation, and the insurance companies, who cast a critical eye on results, refuse to endorse it.

For the past four years the authors have been trying to improve the technique of tendon transplantations for damaged fingers. It seemed to us that if there were a possibility of reconstructing a smooth-walled tendon sheath to replace the scarred one, there would then be a possibility of implanting a new tendon and retaining its gliding function. One of us (N. R.) called attention to the work of Prime of the Columbia College of Physicians and Surgeons. Prime pursued his investigations under the direction of Dr. William Clark and made a systematic attempt to find out a method of preventing adhesions following operations on the brain. He discovered that chemically pure celloidin did not produce the typical foreign-body reaction, but that the surface of the celloidin became coated with smooth tissue whose flattened cells resembled those lining the wall of the tendon sheath. At that time Prime had made no mention of the possible application of this fact to tendon surgery. Animal experiments, in which the authors implanted tubes of chemically pure celloidin surrounding the Achilles tendon of a rabbit, confirmed Prime's results and indicated that a sheath could be built up around the tendon which in many respects resembled the normal lining of the tendon sheath. The exact mode of application to damaged finger tendons was for many months so puzzling as to baffle us. Many plans were tried and were

unsuccessful, but finally the following procedure was devised and has given sufficient success to warrant publication.*

PREPARATION OF CELLOIDIN TUBES

First, it was necessary to make celloidin tubes of varying sizes corresponding to the tendon sheaths of different hands. These celloidin tubes had to have perfectly smooth surfaces, since, if any roughness were present, the characteristic smoothness of the tissue enveloping the tube would be lacking. After experimenting with numerous methods, we were compelled to follow the slow-evaporation method, since it alone gave us tubes of satisfactory smoothness and hardness. A thick solution of chemically pure celloidin (pyroxylin, guncotton) is made by dissolving it in acetone. The solution is poured slowly into test tubes of varying sizes. We have found three sizes to be sufficient. The diameters of the tubes used are as follows: large, one centimeter; second size, eight-tenths of a centimeter; small, six-tenths of a centimeter.

The pouring must be done very slowly, so that air bubbles do not accumulate in the tube. The tubes are placed upright in an incubator at 37 degrees, centigrade, and allowed to evaporate very slowly. This gets rid of any remaining air bubbles. As the acetone evaporates and the level of the fluid becomes lower, additional solution is added in order to keep the test tubes filled to the brim. This process must be repeated about once a week during the first three months; evaporation is usually complete at the end of four or five months. When on inspection of the test tubes the celloidin seems to be sufficiently hard, the test tube is broken with a gentle blow of a hammer and the celloidin tube can then be removed. The outside diameters of the completed tubes correspond to the inside diameters of the test tubes used.

The celloidin tubes are kept in a solution of distilled water until the time of the operation. They are then sterilized by immersion in a 1 to 2000 solution of oxycyanate of mercury just as is employed in sterilizing a cystoscope. The immersion should not last longer than twenty minutes. In our first attempts at sterilization, the tubes were left in for several hours and their surface then showed a greenish scum, evidently due to dialysis of the mercury solution. This destroyed the smoothness of the celloidin tube and interfered with the smoothness of the enveloping tissue.

OPERATIVE TECHNIQUE

The operation is done in two stages. The first consists in a complete resection of the scarred tendon sheath and damaged tendons and the implantation of the celloidin tube. This tube must reach from the proximal stumps of the tendon down to the distal attachment of the flexor profundus at the base of the distal phalanx. The incision for this extensive

* A preliminary report of the celloidin-tube method was published in the January 1936 issue of *The American Journal of Surgery*.

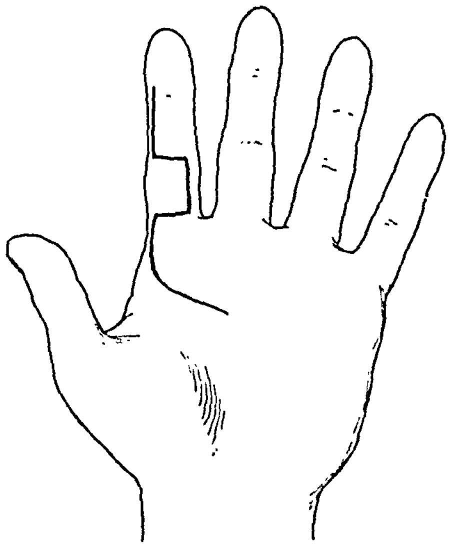

Fig. 2

Typical incision for first stage of the operation in a case of divided flexor tendons of the index finger. The incision follows the normal creases of the palm and fingers.

operation should follow the normal creases of the palm and fingers. Bunnell has shown that keloid formation can be avoided if incisions do not cross the creases at a right angle. Figure 2 indicates the type of incision which has been used most frequently. Slight variations from this general plan have to be made to suit each patient. The skin and subcutaneous tissues are dissected back with particular care to avoid damage to the sensory nerves. When the finger itself is being worked on, the palmar flap should be made as thick as possible, since this will serve to cover the celloidin tube more effectively and will eventually help to replace the normal vincula and thus act to hold the tendon against the phalanges. All of the scar tissue is carefully removed by sharp dissection. The distal portions of both the flexor sublimis and the flexor profundus tendons are excised. If possible, a half-inch stump of the flexor profundus tendon is left to serve as an anchorage for the tendon graft to be implanted at the second operation. The proximal stumps of the flexor sublimis and the flexor profundus are then located and the elasticity of their muscles is investigated. In some instances, when many months have intervened between the accident and operation, the muscles of the damaged finger have become so atrophic and shrunken that there is practically no elasticity left in their fibers. If this fact is elicited at the time of the first operation, it simplifies the plan for the second stage. The celloidin tube is next implanted (Fig. 3). It occupies the space left by the resection of the tendons and the scarred sheath. It is held in place proximally by a single stitch taken through it and the proximal stump of the flexor profundus tendon in such a way as to hold the tendon within the tube; it is attached distally by a second similar stitch which anchors the distal

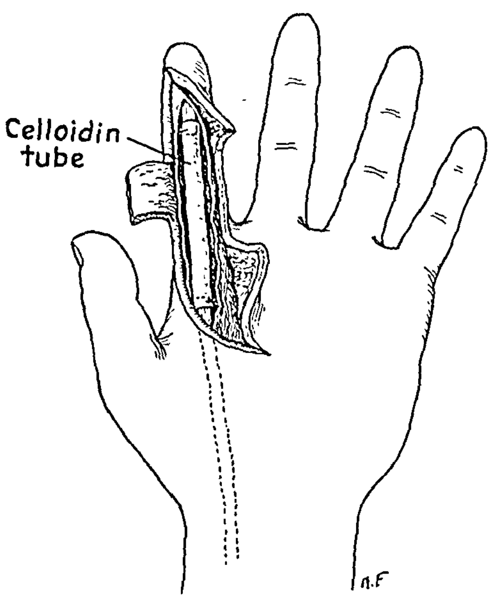

Fig. 3

Implantation of the celloidin tube after excision of scarred tissue. The tube is held in place with two stitches passing through the proximal and distal stumps of the flexor profundus tendon.

stump of the flexor profundus tendon within the tube. The authors have attempted various methods of avoiding a long incision by tunneling and undercutting, but thus far have not found any method which gives as adequate an exposure as the one described. When the tube is in place, the subcutaneous tissues are united over it by a series of fine interrupted stitches. There must be a complete covering of the celloidin tube by this process. Finally, the skin is also united by fine interrupted stitches, great care being taken to secure accurate approximation of the skin edges. A light splint, usually of plaster-of-Paris, is then applied so as to give fixation to the finger which has been operated upon.

The second stage is performed from four to six weeks after the first. A longer period of immobilization might seem advisable, but is accompanied by the danger of increasing the stiffness of the finger joints, which must of course be avoided. The plan of the second operation depends upon the condition of the muscles as ascertained at the first operation. If the muscles of the damaged tendons are in good condition, the operation is done as follows: A two-inch palmar incision is made approximately at the level of the proximal stumps of the divided tendons (Fig. 4). The incision is deepened to the level of the celloidin tube and the proximal tendon stumps are lifted out of the tube. A second incision is then made near the tip of the injured finger. This consists of a short transverse incision in the distal crease of the finger and a half-inch vertical prolongation along the side of the finger, thus making a short L-shaped incision. As the subcutaneous tissues are dissected away, the distal portion of the celloidin tube becomes visible. Within it lies the stump of the flexor profundus tendon. This is lifted out of the tube and a probe, threaded with a silk guide suture, is passed through the length of the celloidin tube and out in the region of the proximal tendon stumps. The celloidin tube is then grasped with a clamp and gently withdrawn from the finger, leaving the guide suture in place. In every instance the tube has been found completely enveloped by a smooth, glistening membrane whose surface closely resembles the normal lining of a tendon sheath. Within the tube is usually found a small quantity of clear straw-colored fluid, similar in appearance and consistency to the secretion of the normal tendon sheath. The operator then returns to the palmar incision and frees the proximal stump of the flexor profundus until normal tendon is visible. As a rule, the stump is scarred for approximately one inch. A No. 2 Deknatel silk

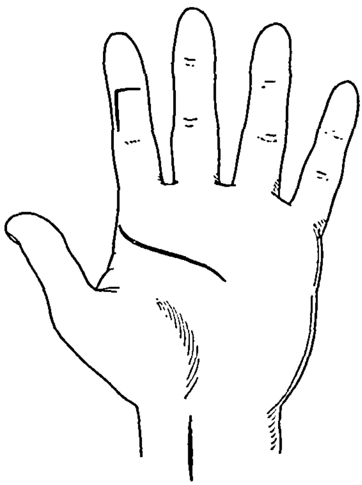

FIG. 4

Incisions for the second stage of the operation in a case of division of the flexor tendons of the index finger. As in the first stage, the incisions follow the normal creases. The incision above the wrist may be made transverse or vertical.

stitch is then inserted, beginning three-eighths of an inch proximal to the level of normal tendon. The stitch used is that already described by Bunnell and Mayer in previous communications. Figure 5 indicates the manner in which the stitch is inserted. Two small cambric needles, preferably with calyx eyes, are threaded with a ten-inch length of silk. The operator notes carefully that level of the tendon where its surface is covered with normal gliding cells, and inserts the first needle horizontally, three-eighths of an inch proximal to this point. The scarred tip of the tendon is grasped with a tendon clamp to facilitate passing the needle with minimal trauma. The same needle is then reinserted into the tendon, this time obliquely in a distal direction at an angle of about 45 degrees, so as to emerge on the opposite side of the tendon. The points of exit and entry of the needle must be as close together as possible so as not to leave silk exposed on the surface of the tendon, since this would tend to form adhesions. The needle is then reinserted a third time, also at a 45-degree angle, and is brought out close to that level of the tendon which the operator has previously noted as the termination of normal tendon tissue. With the second needle two stitches are taken at an angle of 45 degrees. These stitches cross the first series, and emerge at a point 180 degrees opposite the first. The traumatized tip of the tendon is cut off horizontally with a sharp knife just distal to the emergence of the silk sutures. The surface of the tendon should then show a normal cross-section. The two needles are removed and the silk strands are pulled taut, in order to take in all the slack. As this is being done, the silk, emerging from the sides of the tendon, will be seen to force its way between the tendon fibrils, so as to emerge near the center of the tendon. When this stitch has been properly inserted, no silk should be visible on the surface of the tendon, the two free ends should emerge near the center of the cross-section, and the operator should be able to exert at least five pounds of traction on the silk without causing it to tear out of the tendon.

If the distal stump of the profundus tendon is three-eighths of an inch long, it is suitable for the distal anchorage of the transplanted tendon and a corresponding stitch should be inserted into it. If, however, the distal stump is too short, a small drill hole must be passed through the base of the distal phalanx. In some cases the authors have used a drill hole passed in an anteroposterior direction; in others, a drill hole in a lateral direction has been employed. It is not easy to drill these holes without trauma and, for that reason, whenever possible, direct attachment to the tendon stump is a preferable procedure.

The next step is the implantation of a free tendon graft. The operator has a choice of various tendons, but, as a rule, the one best suited is the proximal intact portion of the flexor sublimis of the injured finger. One stump of this has already been exposed in the palm. The proximal portion of the tendon is easily exposed by a one-inch incision placed just above the wrist. When slight traction is exerted on the tendon in the palm, it can be identified above the wrist. It is freed in the palm by

FIG. 5

A: Insertion of the tendon stitch into the flexor profundus tendon. The scarred tip of the tendon is grasped with a tendon clamp, and the needle, threaded with No. 2 Deknatel silk, enters the tendon three-eighths of an inch proximal to the scarred portion of the tendon.

B: The tendon stitch has been inserted with the two ends emerging just proximal to the scarred tip of the tendon. With a sharp knife the tip is now cut off just beyond the point of emergence of the silk.

C: Diagram illustrating the course of the silk through the tendon.

D: The tendon suture has been inserted into the stump of the profundus and into the free tendon graft. The free ends have been pulled taut and have forced their way between the tendon fibrils, emerging near the center of the cross-cut of the tendon. The sutures have been passed about one another preparatory to knotting.

E: The tendon suture completed. The ends have been tied with slight tension so as to produce a little buckling of the tendon ends. The ends lie buried between the coapted tendons.

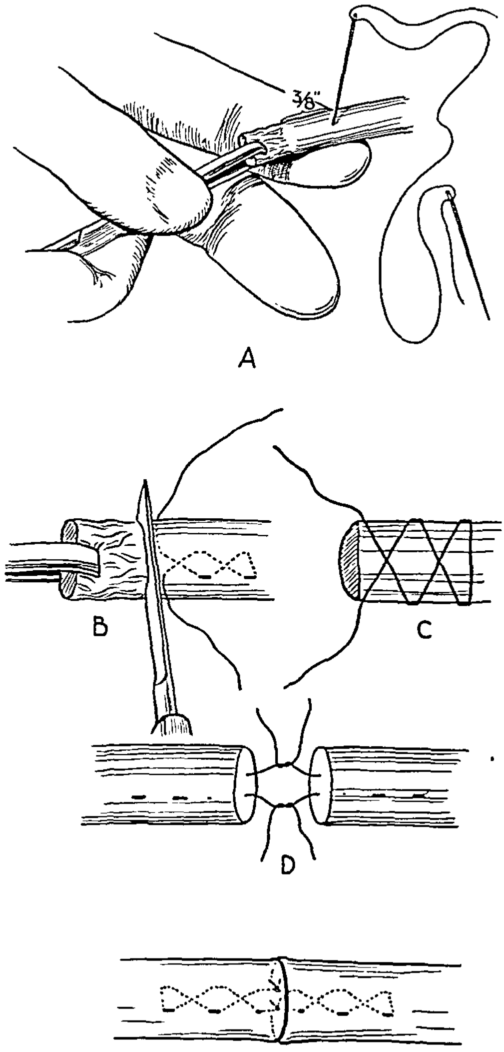

FIG. 5

undercutting with the scissors until the tendon enters the carpal sheath. With a gloved finger placed around the tendon above the wrist, it is then possible with a snapping motion to pull the tendon out of the sheath. The free end is then threaded with the typical tendon suture as already described, and the tendon is divided at its musculotendinous junction. The ends of the suture are left sufficiently long so that they can be looped through the guide suture and the tendon can be pulled down through the reconstructed digital sheath. The graft itself should be somewhat longer than the distance between the stumps of the flexor profundus tendon. The operator must next determine accurately the length of the transplanted tendon. This is one of the most difficult parts of the operation, since too long a tendon will fail to give adequate flexion and too short a tendon will produce a contracture, usually of the terminal phalanx of the finger. The following method gives the best results: The wrist and finger are held at 180 degrees, and the proximal stump of the flexor profundus tendon is pulled on by means of the stitch already inserted until the

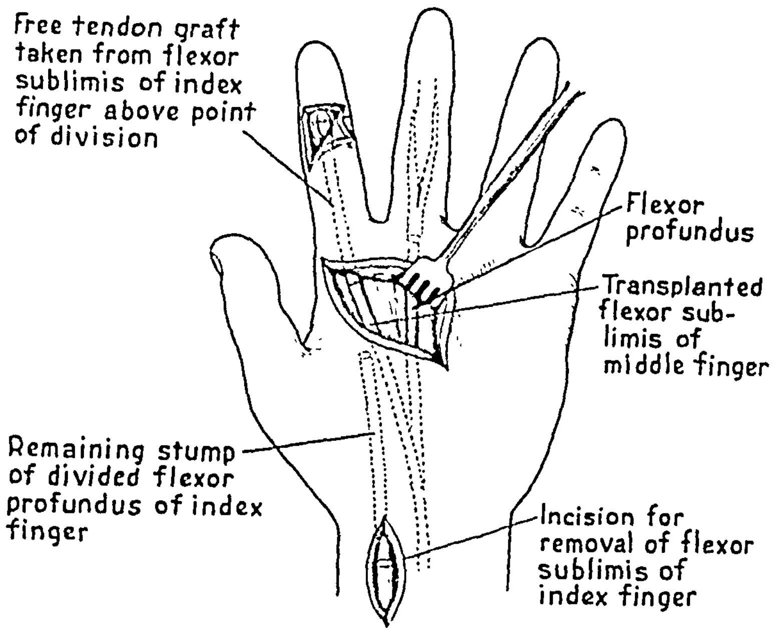

FIG. 6

Transplantation of the flexor sublimis of middle finger, lengthened by a free tendon graft taken from the flexor sublimis of the index finger to replace the divided flexor tendons of the index finger. The transplanted tendons run through the sheath enveloping the celloidin tube.

limit of extension of the muscle has been reached. With a probe, the distance is now measured between the proximal and distal stumps of the flexor profundus tendon. This gives the accurate measure of the length of the graft. Its unthreaded end is then cut, in order to shorten it sufficiently; a No. 2 Deknatel silk suture is inserted at this end; and the sutures are then tied to the corresponding sutures of the profundus tendon, so as to splice the transplant between its two stumps. In tying the sutures, enough tension should be put on the silk to cause the tendon ends to buckle slightly. This helps to give accurate approximation of the tendon fibrils to one another. The union of the tendon must be sufficiently accurate so that no raw tendon surface is visible at any point, but everywhere the operator sees the smooth, gliding surface of the tendon. The knots are buried between the opposing ends of the spliced tendons. When the stitch has been completed, the finger ought to bend slightly as it is released by the operator. The operator should with ease be able to straighten the finger completely without inducing any separation at the lines of the tendon suture. The operation is completed by interrupted subcutaneous stitches and skin stitches.

If the muscles of the damaged finger tendons do not appear capable of regeneration, it is wiser to utilize the sublimis muscle of the adjacent finger as the activating power. The tendon of the adjacent sublimis is exposed near the metacarpophalangeal joint, is divided in this region, is threaded with the silk suture, and is then prolonged by means of a free tendon graft exactly as in the operation just described. (See Figure 6.)

AFTER-TREATMENT

The details of the after-treatment are no less important than those of the operation, and it is only by following them precisely that we have been able to secure gratifying end results. After the tendon transplantation, the finger is again splinted in order to avoid any undue strain on the grafted tendon. It is advisable to have the finger straight, since otherwise flexion contractures readily develop. Passive motion of the finger which has been operated upon should be begun as soon as the wound is healed, usually on the seventh or eighth day. Active exercises, combined with sinusoidal stimulation of the muscles, are begun on the ninth or tenth day. If active motion is begun sooner, there is danger of tearing the tendon ends apart. Owing to trauma and muscle disuse, the motion of the transplant is at first pitifully slight, but, as the exercises and physiotherapy are kept up, the motion increases from day to day. The physiotherapy must be continued for many weeks—in some cases several months—until function has been regained. Sinusoidal stimulation of the affected muscles is invaluable, since the patients are at first unable to contract them voluntarily. With the aid of the electric stimulus, the patients gradually learn muscle control, but only by dint of patience and persistence can the normal range of contractility be recovered.

In closing this paper, the authors feel that they ought to express a word of warning with regard to the celloidin-tube method. An impression might be gained by some that the celloidin tube exerts a magic power to transform a disabled finger into one with normal function. It is obvious that such an impression is quite erroneous. The celloidin tube is only one detail in a series of extremely complex, delicate surgical procedures. It has only one advantage,—namely, the restoration of the digital sheath which furnishes a physiological pathway for the transplanted tendon. Tendon grafting is a highly specialized surgical technique demanding of its followers not only detailed anatomical knowledge, but constant practice on the cadaver. It is only by frequent repetition that a tendon suture can be inserted with speed and minimal trauma. Unless the surgeon is willing to give adequate study and practice to tendon surgery, it is unfair to the patient, as well as to the celloidin-tube method, for him to undertake the repair of damaged finger tendons by the celloidin-tube implantation.

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ROENTGEN-RAY THERAPY OF BONE TUMORS *

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Roentgen's discovery of the roentgen rays, in 1895, created a new field of research and stimulated the scientific world to apply the peculiar properties of these rays to the advancement of medical diagnosis and treatment.

It was soon evident that there was variation in the radiosensitiveness of different types of tumors. Although all tissue has a measure of radiosensitiveness, it was found that some tumors were comparatively radioresistant or insensitive, as is true of osteogenic sarcomata, whereas others, such as endothelial myelomata, were so remarkably sensitive that diagnostic irradiation became possible.

There exists a considerable difference of opinion as to the therapeutic value of roentgen rays. This is not surprising when one remembers that only forty years have passed since the discovery of the rays. All tumors are not amenable to surgical treatment and certainly all are not radiosensitive enough to be considered susceptible of treatment by roentgen rays. Early roentgenologists gained a foothold in the field of treatment largely through their ability to demonstrate benefit from the use of the rays and cure of certain inoperable and recurring tumors, and, as the favorable results became known, roentgenologists were asked to cooperate with other physicians and surgeons. A combination of surgery and irradiation offers greater benefit than either method alone in certain cases. In other cases, especially those of benign tumor, there is no question that surgery cures quickly and surely, in minimal time, and permits microscopic study of tissue with consequent verification of the clinical, roentgenographic, and surgical diagnosis. The claim that cure has resulted from irradiation, without microscopic proof thereof, is not always tenable. Members of the medical profession look to the teamwork of the family physician, surgeon, roentgenologist, and pathologist to bring about advances in knowledge whereby earlier diagnosis, efficient treatment, and an increased number of cures may be expected. To this end the rôle of the family physician is probably most important, for, if the patient is treated for rheumatism or sprain until the tumor has become obvious, valuable time will be lost and treatment, no matter of what type, will be of lessened effectiveness.

CASE 1. The patient was a housewife, aged twenty-six years. When three months pregnant, she had become conscious of a pain in the left groin, which was aggravated by exercise. Two and a half months later she had noticed a swelling. She had consulted

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her family physician, who advised an immediate visit to the Clinic. Six weeks thereafter she registered at the Clinic; at that time gestation had progressed for seven months.

Examination disclosed a large mass in the left groin, which had bulged into the pelvis and which, it was evident, would render practically impossible delivery of a baby at full

FIG. 1-A

Case 1. Before roentgen-ray therapy. Destruction of left pubic bone from probable endothelial myeloma. A seven-months' foetus is in the uterus.

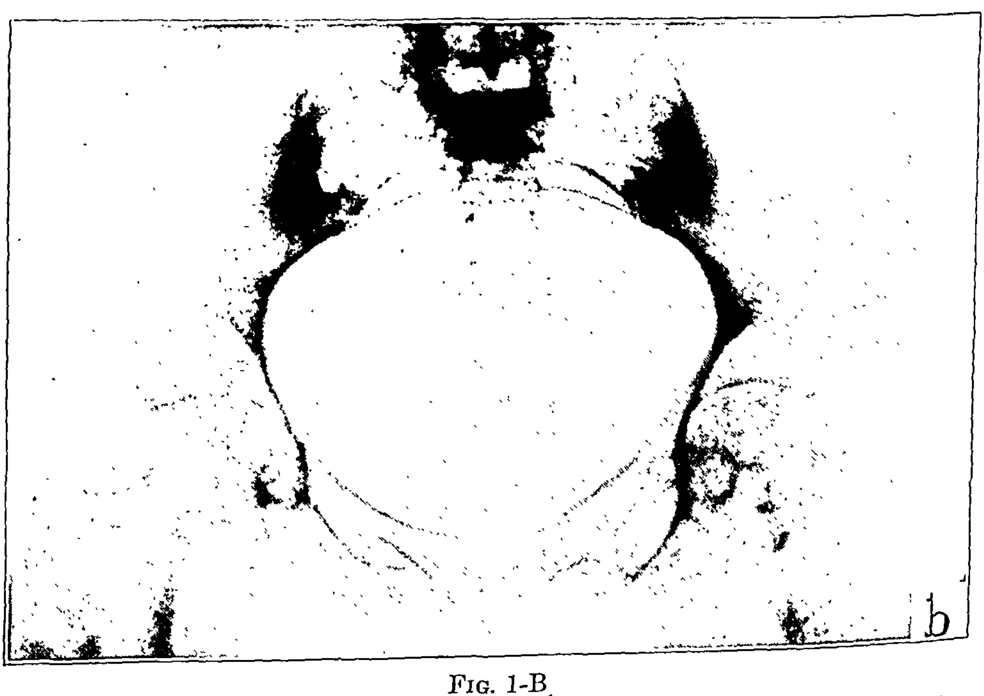

FIG. 1-B

Case 1. Thirteen months after roentgen-ray therapy. Following destruction of the tumor and deposition of bone, the left pubic bone has reformed.

term (Fig. 1-A). Following consultation of a surgeon, roentgenologist, and obstetrician, roentgen-ray treatment was begun the day after the patient's admission. The first course extended over five consecutive days, following which the patient went home with advice to return in one month.

The woman was next seen six weeks later, at which time she said that she had gained eight pounds (three and six-tenths kilograms), slept well, and had a good appetite. The pain was gone and the tumor was appreciably smaller. Three other courses of treatment were given in June, August, and December. The patient gained twenty pounds (nine kilograms) and felt "fine". The tumor regressed clinically and roentgenographically. After the second treatment the patient returned to her home, several hundred miles away, and was delivered of a baby, who died after one week of life. The cause of death was not known.

This case illustrates the value of roentgen-ray treatment (Fig. 1-B). The author believes that no other form of treatment would have been of use in this case; certainly surgery was out of the question. The response to irradiation makes it appear that the tumor was an endothelial myeloma. These tumors tend to metastasize, but, after eighteen months, roentgenograms of the thorax and the clinical examination gave negative results. The patient had had no other treatment.

PREOPERATIVE IRRADIATION OF BONE TUMORS

Preoperative application of irradiation recently has been discussed considerably and the method has gained acceptance in some medical centers. Its field of usefulness, the writer believes, is very limited and its indiscriminate use may be more harmful than beneficial. What is needed is early diagnosis, destruction or removal of the tumor, and prevention of metastasis by whatever means may be available. Effective preoperative irradiation, since it consumes valuable time, may permit metastasis of malignant tumors to occur, and in treatment of benign tumors there is seldom need for such a procedure. On the other hand, a tumor may be so situated and of such a size as to make surgical removal impossible, whereas the growth may diminish in size following irradiation and thus become operable. From the author's observations he cannot see the value of irradiation preceding biopsy, or the value of routinely treating malignant tumors before amputation or

FIG. 2

Case 2. Posterior and anterior views, showing slight enlargement of the left thigh from probable endothelial myeloma of the left femur. The symptoms had been present only one month.

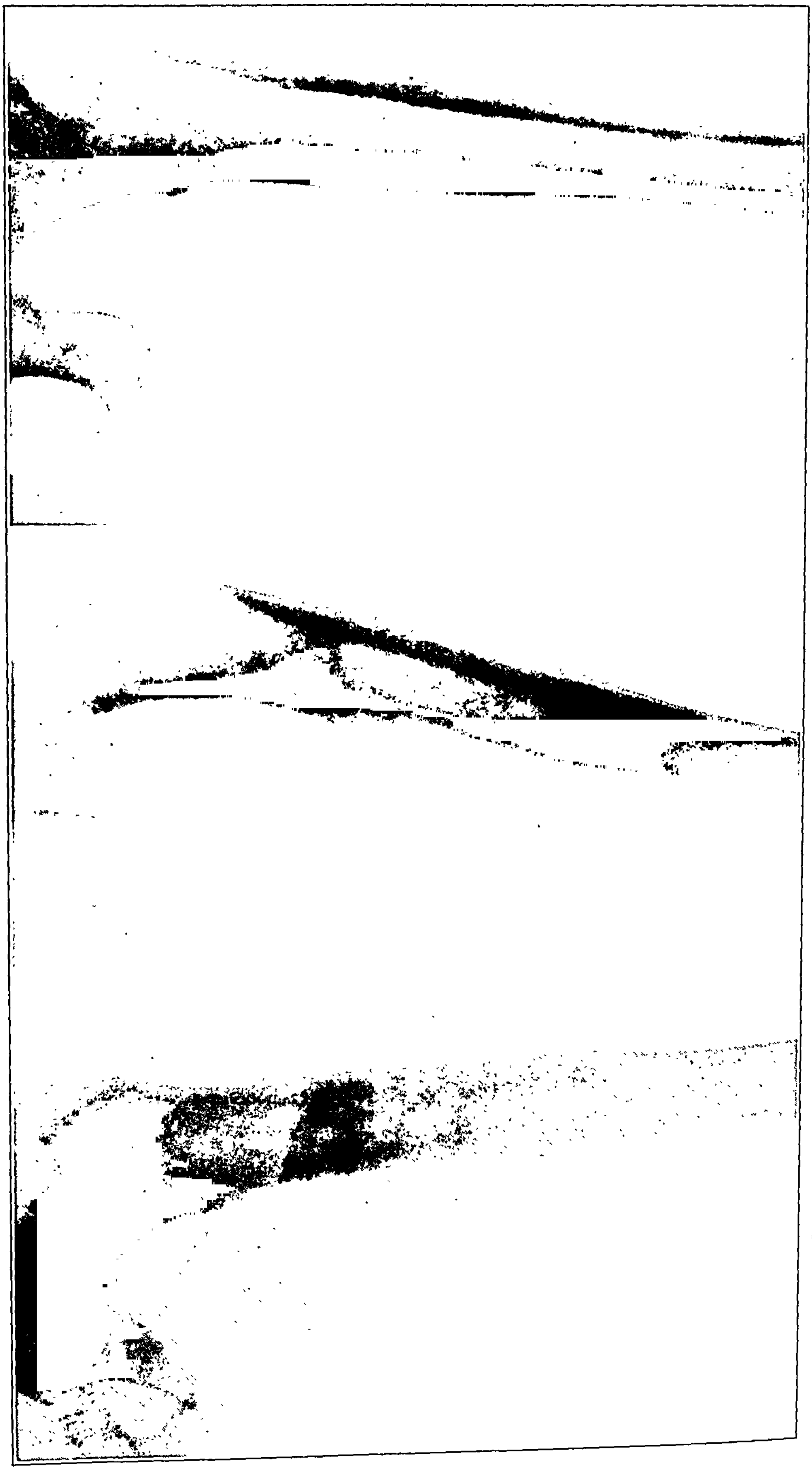

FIG. 3-A

Case 2. Before roentgen-ray therapy, January 1929.

FIG. 3-B

Case 2. After roentgen-ray therapy, August 1929.

FIG. 3-C

Case 2. Roentgenogram, August 1934. The lesion was probably an endothelial myeloma.

excision. Although such treatment may give the roentgenologist an idea as to the radiosensitiveness of the tumor, temporary improvement gives the patient a sense of false security; thus, exploratory operation may be postponed, and the advantages of early and accurate diagnosis, immediate surgical treatment, and examination of tissue by a pathologist may be deferred or lost.

Case 2. (Registry of Bone Sarcoma, No. 1756.) A girl, aged thirteen years, was brought to the Clinic in January 1929. A month previously she had noticed a swelling and had experienced throbbing pain in the upper portion of the left thigh (Fig. 2). These symptoms had disappeared in a week, but about a week before she came to the Clinic the symptoms had reappeared and the pain and throbbing had been worse at night than during the day.

On examination a firm, fixed mass and enlarged veins were found in the lateral aspect of the left thigh. The temperature, the urine, and the leukocyte and erythrocyte counts were normal. The Wassermann reaction of the blood was negative and roentgenographic examination of the thorax gave negative results.

The roentgenographic diagnosis relative to the thigh was periosteal sarcoma. The surgeon's preoperative diagnosis was tumor of indefinite nature. The surgeon also gave the opinion that the growth was too high for successful amputation and he advised biopsy, irradiation, and administration of Coley's toxin. Biopsy was performed, and the diagnosis made from microscopic examination of the tissue was Ewing's tumor.

Three courses of irradiation were given in January, February, and May. Furthermore, Coley's toxins were administered by the patient's home physician in February and May 1929, and administration of these toxins was continued thereafter for six months; injections were made once a week.

In August 1935 a report was received that the girl's general health was good and that she had no trouble with the left leg. She was alive and well over five and a half years following biopsy, irradiation, and toxins.

POSTOPERATIVE IRRADIATION

This method of treatment has been employed following biopsy, excision, curettage, and amputation in the hope that remaining cells may be destroyed, that metastasis may be prevented, or that unrecognizable metastasis may be adequately dealt with. For this reason, the common sites of metastasis and the territory occupied by the lymphatic structures which drain the region of the tumor are irradiated; if the malignant cell present is of a radiosensitive type, there is some hope that the remaining elements will be destroyed. The beneficial effects from this form of treatment partly result from the action of the rays on the blood vessels and the formation of connective tissue; the malignant cells which remain become enclosed in masses of fibrous tissue, of which the blood supply is impaired and growth is thus inhibited. Late recurrence may be explained in this manner in some cases, but the author has seen malignant cells at the site of previous operation and extensive irradiation, when clinical manifestations of tumor were not present. Postoperative irradiation may be one of the reasons why more five-year cures are recorded now than formerly, but the writer thinks an equally important reason is that diagnosis is made earlier than formerly and, therefore, efficient treatment is carried out.

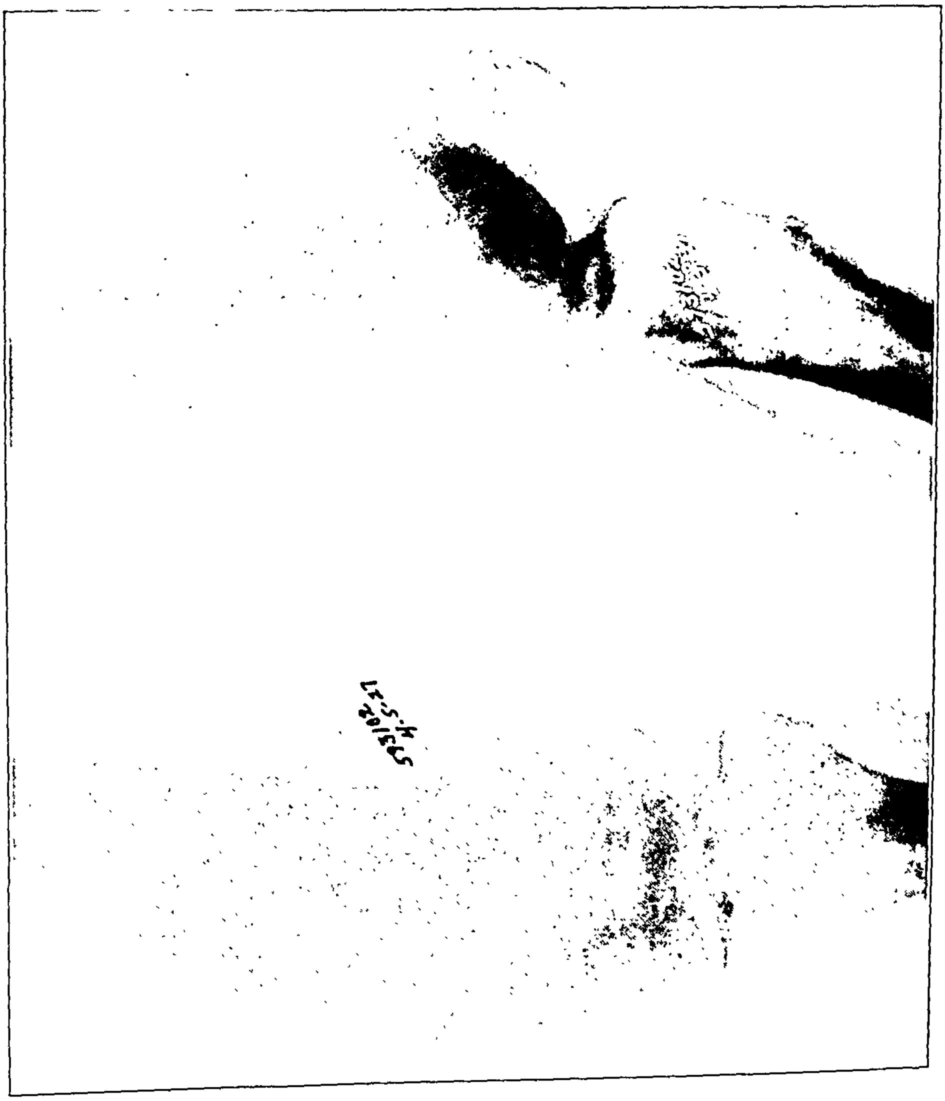

FIG. 4-A

FIG. 4-B

Case 3. Anteroposterior and lateral roentgenograms, showing appearance of the tumor.

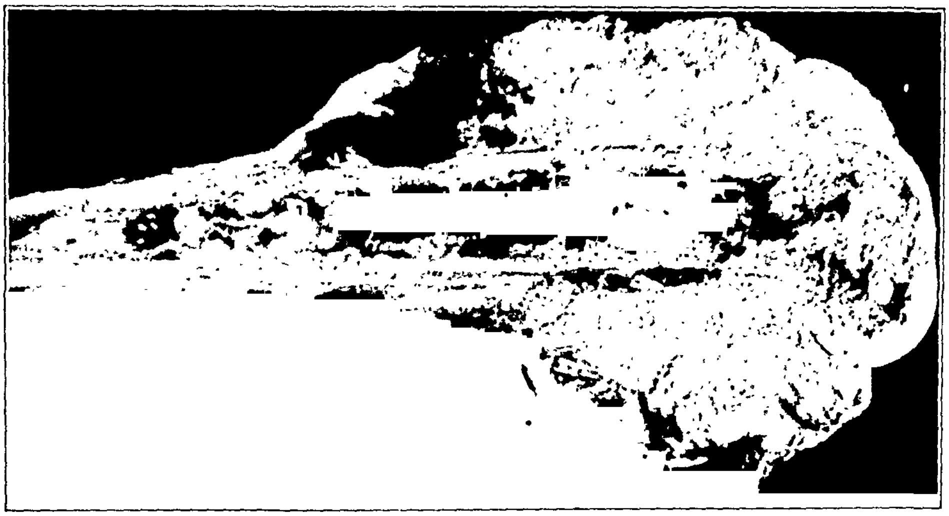

FIG. 4-C

Case 3. Gross sagittal section of the tumor.

CASE 3. In April 1927, the author saw an engineer who complained of having had pain about the left knee for a year and swelling of the lower end of the left femur for four months. He said that his mother's left leg had been amputated for sarcoma.

On examination, the circumference of the left leg was four and one-half inches (eleven and five-tenths centimeters) greater than that of the right leg, and reduction in motion of the left knee limited movement of the leg to the arc between 90 and 160 degrees. The superficial veins were enlarged and there was some local increase in temperature. Roentgenographic examination gave evidence of a soft-tissue tumor (Figs. 4-A and 4-B) and periostitis, involving the lower part of the femur; roentgenograms of the thorax gave negative results. The surgeon advised that a section of tissue be removed for confirmation of a diagnosis of sarcoma, this to be done with tourniquet applied, and, if the pathologist should find evidence of malignancy in a frozen section, that amputation be performed immediately. At operation the tissue was reported to be that of a highly malignant sarcoma, and amputation was performed through the upper part of the femur (Fig. 4-C).

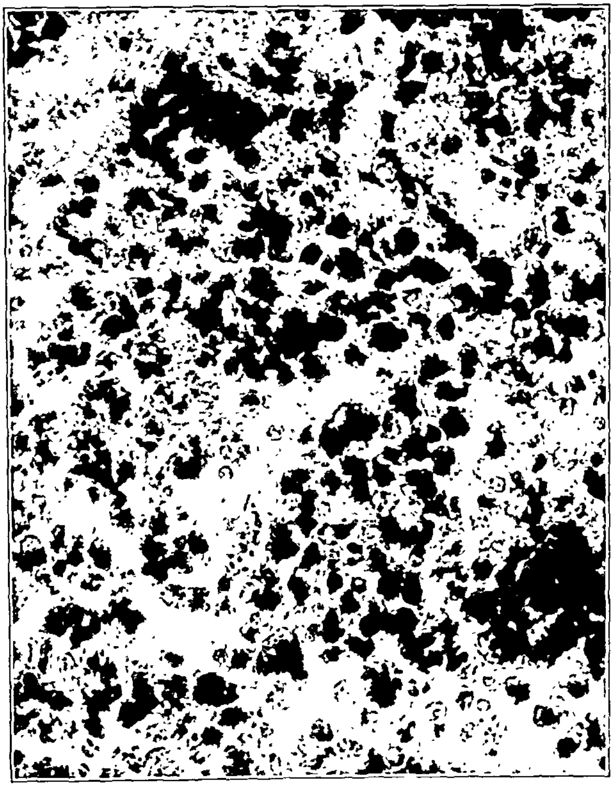

FIG. 5

Case 3. Microscopic appearance of tumor diagnosed by different pathologists as "highly malignant, cellular, round-cell sarcoma" and "endothelial myeloma".

The patient made an uneventful recovery, was given a course of roentgen-ray treatments, and was dismissed one month from the time of his admission. Five years later he reported: "I have taken on weight and am of robust appearance, a physical specimen you would be proud of." In a still later report, his physician stated that the patient was living and well more than eight years after treatment.

This patient was given every care—examination, consultations of surgeon, roentgenologist, and pathologist, operation and postoperative irradiation—and was returned home with his wound healed in one month. He came 2,300 miles, but he saved valuable time thereby; it was not necessary to send roentgenograms or tissue to experts at various distances and to subject him to preliminary irradiation while waiting for their replies. The microscopic slide (Fig. 5) has been examined recently by pathologists. One reported "highly malignant, cellular, round-cell sarcoma"; another, "endothelial myeloma".

SOME FACTORS IN THE REACTION OF TUMORS TO IRRADIATION

The response to irradiation usually will be determined by what cell is predominant. Thus, a certain type of tumor may vary in the degree with which it reacts; it may be wholly or only partially destroyed. There is a difference between the radiosensitiveness of tissues and cells of normal structures on the one hand and the radiosensitiveness of tumors on the other hand. Thus, a mixed-cell tumor may have a great proportion of radiosensitive cells and for a time may retrogress rapidly. After these radiosensitive cells have been destroyed, the remaining, more resistant cells continue to grow and are not affected by continued irradiation. Knowledge is accumulating as to the methods of application of irradiation to tumors of various situations and various cellular classifications; at present, repeated courses of protracted fractional irradiation, with cross-firing, appears to be the most satisfactory method. Roentgenograms should be made from time to time in order to visualize the effects of irradiation. As one becomes acquainted with the course of bone tumors, one learns not to be alarmed by temporary increase in swelling, pain, or redness, or by local increase in temperature and by what may appear, in the roentgenograms, to be evidence of increase in absorption of bone, such as is seen in certain cases of giant-cell tumor.

Fig. 6

Case 4. Secondary sarcoma of the left ilium, on the basis of an old osteochondroma.

BENIGN OSTEOGENIC TUMORS

These tumors commonly are known as exostoses, osteochondromata, chondromata, and fibromata. They are relatively insensitive to irradiation. Because they are readily cured by surgical operation, treatment by roentgen rays has received little attention. If there is doubt as to the malignant transformation of a tumor of this group, the author favors excision and postoperative irradiation; the tumor must be entirely re-

moved, especially if it is a chondroma, and, if doubt exists as to its having been completely eradicated, the actual cautery is employed.

CASE 4. In May 1925, a farmer, aged thirty-nine years, was referred to the Clinic by his family physician, because of a tumor of the left hip. Eight years before, the patient's pelvis had been crushed in an accident. A year later he had begun to have pain in the left buttock, and eighteen months after the accident a mass was discovered in the upper part of the left femur. The tumor was not tender and annoyed him only on motion. It enlarged slowly and after five years of growth a surgeon had removed it. The patient was told that it was a sarcoma. It recurred in three weeks and the patient was given a series of twelve roentgen-ray treatments; however, the mass continued to enlarge at about the same rate as before.

On examination (Fig. 6), a huge, fixed, hard tumor was found, extending about the ilium; the scar of the previous operation was evident. Three surgeons were of the opinion that the tumor was a chondroma, undergoing malignant change, and advised excision followed by irradiation. Urinalysis and examination of the blood, including the Wassermann reaction, gave negative results. The patient looked well and was of good weight.

At operation a huge osteochondroma, weighing three and one-half pounds (one and six-tenths kilograms), was excised from the ilium. The tumor extended from the femoral trochanter up into the abdomen to the spine, and had pushed the femoral artery inward. A poor prognosis was given by the surgeon. The pathologist made a diagnosis of osteochondroma. A course of three roentgen-ray treatments was given and the man was referred to his local roentgenologist for continuance of the irradiation.

Eighteen months later the patient wrote that recurrence had taken place. Twenty-seven months after the author had operated the patient's physician wrote that he had operated in order to drain a large amount of serosanguineous material and pus, because the patient was toxaemic and had a high fever. A month later the patient died of "malignant disintegration of the tumor", more than ten years after the tumor had first been noted.

BENIGN GIANT-CELL TUMORS

There has been considerable difference of opinion as to the relative merits of surgical operation and irradiation for the treatment of this group of bone tumors. Certainly all are not susceptible of surgical treatment, in view of their situation, their size, and the danger of hemorrhage and infection. For this type of giant-cell tumor, irradiation is advisable. In these cases, considerable judgment is required in order to determine the most advantageous form of treatment and the author cannot agree with some who believe that radiotherapy has solved the problem. Most of these tumors, excluding those of the jaws, occur in the lower end of the femur, the upper end of the tibia, or the lower end of the radius. They are usually discovered while yet of such size as to permit of surgical removal with minimal expense and loss of time. It is well to remember that the roentgenographic characteristics of benign giant-cell tumors do not always determine absolutely the absence of malignancy, whereas, if operation is performed, the opportunity is afforded to have a microscopic diagnosis made from frozen sections of tissue while the surgeon is at work. Prolonged irradiation of young individuals may lead to regression of tumors and to deposition of bone after a period of months or years, but at the expense of considerable money and of possible extensive damage to uninvolved tissue. The experienced surgeon may accomplish a cure in a

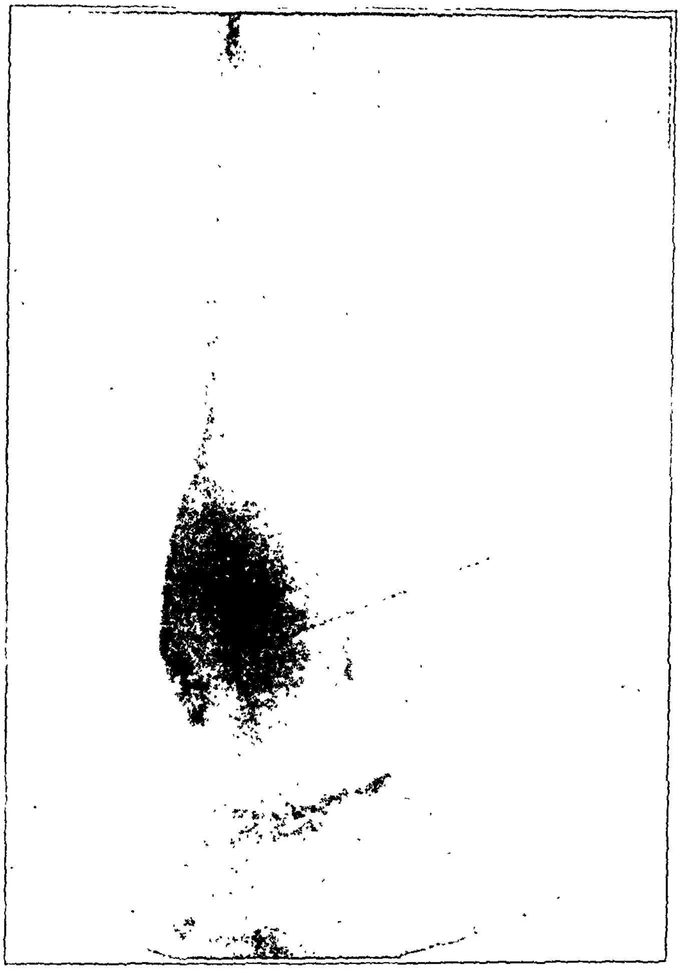

FIG. 7

Case 5. There is evidence of absorption of bone on the mesial side of the femur, including both the diaphysis and the epiphysis. The tumor bulges into the soft tissues. The outline of the tumor is not clear and lines or striations cannot be seen in the mass.

few weeks and be sure of what type of tumor he has to treat, in most cases. The writer realizes that the older accounts indicate that amputation was performed in a high percentage of cases, that infections were common, and also that control of hemorrhage was difficult. All of this makes it appear that operation was attended by undue surgical risk, but surgeons have perfected their technique and, in the author's opinion, surgical operation maintains first place as a means of treating this tumor.

CASE 5. A woman, aged twenty-two years, came for consultation in October 1917, complaining of having had pain, swelling, and stiffness of the left knee for five months. She had been told that she had a sarcoma and "injection treatment had been given". The tumor had increased in size, disability had increased, and amputation had been advised. She came to the Clinic seeking to avoid amputation.

On examination, the roentgenologist believed that a sarcoma was present (Fig. 7). Nevertheless, the surgeon advised exploration and microscopic examination of tissue; this was accepted by the patient and the growth was found to be a benign, giant-cell tumor. The tumor occupied the mesial side of the lower epiphysis and part of the shaft of the femur, and it contained reddish, jamlike tissue. The cavity was curetted until every vestige of tumor had been removed; then the cavity was cauterized with the actual cautery and packed with gauze; and fifty milligrams of radium was left in the cavity for twenty-four hours. Three weeks later another radium treatment was given, making a total of 1,750 milligram hours. The patient was dismissed on the twenty-sixth day after operation and returned home.

Eighteen years later she reported that she was married and well.

This case illustrates the value of biopsy and the opinion of a competent pathologist before advising amputation. This case was encountered a number of years ago and the rapid growth and roentgenographic appearance led to the diagnosis of malignancy. Although irradiation might

have relieved the condition, the time required would have been long. By means of the combined treatment, the patient was relieved of her anxiety, became cured, and in twenty-six days returned to her home, which was 1,500 miles away.

Ordinarily, complete removal of these benign growths will effect cure. Some reach such size as to make operation hazardous. Joints may be involved, but they seldom are. Rarely are these tumors of such size as to require amputation, but extensive involvement, injury to joints, infection, or excessive irradiation may so damage the tissue as to produce a useless limb. Irradiation is preferred for tumors that are inaccessible to surgical removal, as are those of the spinal column and bony pelvis.

HEMANGIOMA

Hemangioma affecting bone is moderately radiosensitive and under moderate dosage, repeated at regular intervals for a number of months, gradually regresses until healed.

HEMANGIO-ENDOTHELIOMA

Hemangio-endothelioma is less radiosensitive than endothelioma or hemangioma and tends to improve temporarily under irradiation.

ENDOTHELIAL MYELOMA

Endothelial myeloma is the most radiosensitive of bone tumors, and complete regression of the local growth may be observed under irradiation competently applied. So uniform is the response to irradiation that diagnostic irradiation has been advocated and is considered sometimes to prove more reliable than the opinion of the average pathologist. While

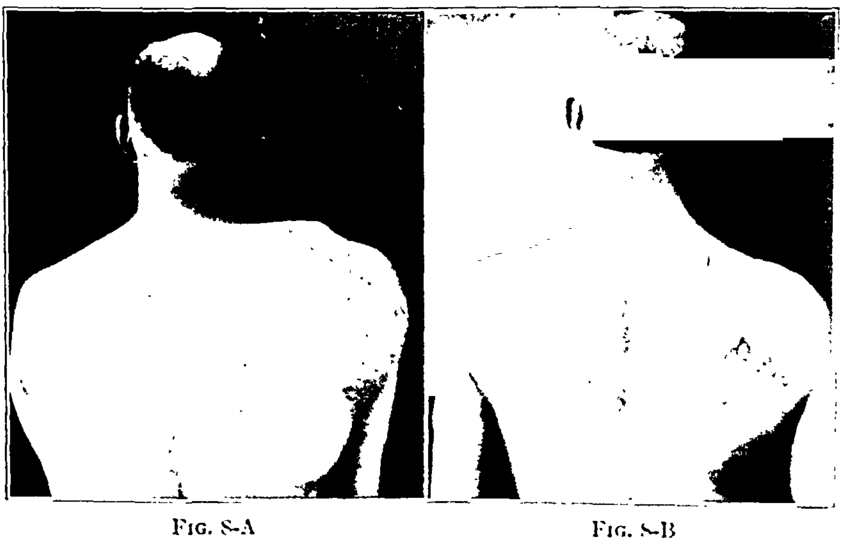

FIG. 8-A FIG. 8-B

Case 6. Osteogenic (Ewing's) tumor of the right shoulder.
Fig. 8-A: Appearance of patient on admission.
Fig. 8-B: After irradiation.

the tumor and symptoms may disappear under treatment and the bone may assume normal appearance, the treatment often fails to effect cure because of metastasis. Early radiotherapy, before metastasis has occurred, may result in permanent cure. Opinion as to the merits of treatment recently appears to favor amputation, irradiation, and administration of Coley's toxins.

Case 6. In July 1930 a farmer, forty-eight years of age, arrived at the Clinic, complaining of pain in the right shoulder. He said that four years before, while cranking an automobile, a back-fire of the motor had injured his right shoulder. The pain of the injury had persisted and three months after the accident he had noticed swelling over the right scapula. This swelling had continued to enlarge. About three years before he came to the Clinic the tumor had been excised and a diagnosis of sarcoma had been made. In the next three years, excision was performed twice, but the tumor had recurred.

On examination, the man was found to be of normal weight. A large tumor, with scars of the previous operation, was found over the right scapula (Fig. 8-A). The tumor was fixed, of generally rubberlike consistency, and contained softened portions. Urinalysis and examinations of the blood gave negative results. The roentgenogram of the thorax was negative. The diagnosis, both of roentgenologists and of surgeons, was osteogenic sarcoma. Extensive amputation was considered, but was abandoned in favor of irradiation. Examinations of the tissue obtained by the home physician resulted in a diagnosis of Ewing's tumor.

Courses of irradiation were given in July, October, and December. The patient made marked general improvement and gained weight (Fig. 8-B). The tumor decreased rapidly in size.

In March 1932 a large metastatic growth appeared in the right ilium and skull, and courses of irradiation were given. By July 1933, the tumor of the skull had disappeared and that in the ilium had greatly diminished in size. At that time another course of irradiation was given. In February 1934 the home physician irradiated the left shoulder and reported that there was metastasis in the lungs. The patient died from metastasis in July 1934. This was about eight years from the time of discovery of the tumor.

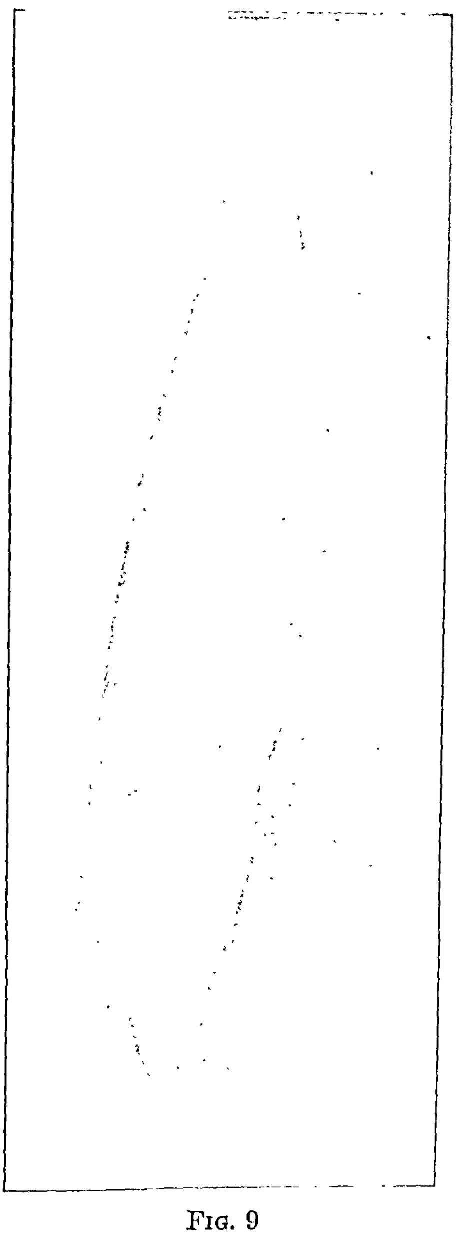

Fig. 9

Case 7. Destruction of the ulna caused by osteogenic sarcoma with infection.

OSTEOGENIC SARCOMA

Osteogenic sarcomata, as a group, are highly resistant to irradiation and, although some regression of symptoms may follow such treatment, its principal

value in the author's opinion is that it gives relief of pain in conjunction with surgery. Studies in the larger clinics and data assembled by the Registry of Bone Sarcoma do not hold out much hope of permanent benefit from irradiation; excision and amputation appear to be most beneficial. As some patients will not consent to operation, irradiation may be chosen. The writer is not impressed by the use of irradiation as a preliminary form of treatment and believes early diagnosis, radical surgical operation, postoperative roentgen-ray therapy, and administration of toxins have given the most encouraging results.

CASE 7. A girl, aged seventeen years, came to the Clinic in May 1931, because of pain in the arm, following a sprain of the left wrist eighteen months before. Recovery from the sprain had been slow, but the patient had been able to play basketball. About a year before she came to the Clinic the left arm had swollen somewhat, but there had been no soreness or fever. About that time, a roentgenogram had been made and a diagnosis of greenstick fracture had been given. Splints had been applied and left in place for three weeks, but the pain had continued and the splints had been removed. They had been replaced, however, and the patient was wearing them when she arrived at the Clinic. She said that a diagnosis of osteomyelitis had been made, and that an area of redness had been incised six weeks before the writer saw her. She had lost ten pounds (four and five-tenths kilograms) in three weeks, and her appetite was poor. An interesting feature of the history was that a sister had undergone amputation of a leg for sarcoma.

On examination, the lower third of the left arm was swollen and red, and pus was draining from the wound of the previous excision. Flexion contracture of the fingers and wrist was present. The temperature was 101 degrees Fahrenheit and the pulse rate was 120 per minute.

Physicians, surgeons, and roentgenologists made a diagnosis of malignant sarcoma of the left ulna (Fig. 9). Amputation was advised, but the patient refused to submit to it. Biopsy was performed, however, and the pathologist reported osteogenic sarcoma, grade 4.

In May, June, and July courses of irradiation were given under the following conditions: 135 kilovolts, 5 milliamperes, 6 millimeters of aluminum filtration. Ulceration and sequestration occurred and the arm appeared shrunken as compared with the condition before biopsy and irradiation. The patient gained four pounds (one and eight-tenths kilograms) in four months. Six months after the biopsy, a sequestrum was removed from the mass in the forearm. The patient's family doctor wrote that she died a "pulmonary death" seventeen months after biopsy.

MULTIPLE MYELOMA

Multiple myeloma presents a hopeless surgical problem, and irradiation gives only mildly encouraging results. Relief of local symptoms when the disease is recognized early, and some retardation of growth, with considerable improvement for a period of about one to two years, is about all that there is to look forward to. The disease is fatal in spite of any known treatment.

METASTATIC CARCINOMA

In cases of metastasis from carcinoma of the breast, thyroid gland, uterus, stomach, and prostate gland, a measure of relief from pain may be given and rapidity of growth may be delayed by roentgen-ray therapy, but the generalized process goes on and the benefits frequently are of ques-

tionable value. These metastatic growths often are considered as primary bone tumors and their true nature remains undiscovered until late in the disease or until necropsy is performed. Nevertheless, the author believes that the prolongation of life and relief of pain obtained through roentgen-ray therapy would cause anyone afflicted to choose this method of treatment.

COMMENT AND SUMMARY

It is obvious from experience extending over a period of years, that roentgen-ray treatment of bone tumors is not a cure-all. On the other hand, it has an important field of usefulness. The possibilities of irradiation have not been exhausted and time will bring about greater improvement in its application and increase its therapeutic value. Surgeons and roentgenologists must go on cooperating to improve results; when the family physician is able to make the diagnosis earlier, and if he will then refer patients to centers where every aid is available, progress through further research will follow.

DIFFICULTIES IN THE DIAGNOSIS OF BONE TUMORS*

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Even a brief experience with bone tumors reveals the difficulties which surround diagnosis,—the history of the case may not be distinctive; the physical examination may reveal little; and the roentgenographic examination, though of the utmost value and the most important single means of examination, may be misleading. It is the purpose of this paper to discuss certain problems in diagnosis which the author has encountered.

There are available four sources of information from which facts may be obtained for the purpose of reaching an accurate diagnosis,—namely, history, physical examination, roentgenographic examination, and biopsy. From each, valuable information can be obtained, but each also has its limitations.

Too much emphasis cannot be laid upon the importance of a carefully taken history in which especial attention is paid to those features which concern lesions, such as syphilis and osteomyelitis, which are often confused with bone tumors. Yet, at its best, the history rarely yields sufficient information to permit a more accurate diagnosis than malignancy, leaving the determination of the type of bone tumor to other methods.

The importance of the history is revealed by the following case.

CASE 1. W. F., a male, aged twenty-eight years, first experienced pain in the right thumb in May 1935. In July 1935, swelling along the metacarpal was first noticed. The swelling increased rather rapidly and then remained stationary. Pain, at first not severe, slowly increased in intensity until the patient was compelled to give up his work as a carpenter.

His general health had been good save for acute appendicitis ten years previously. Some time after appendectomy, the scar had bulged. Operation, undertaken for the repair of ventral hernia, had revealed tuberculous peritonitis. The patient had been obliged to remain in bed eleven months from June 1925 to May 1926. In 1928 he had had an attack of gonorrhoea.

Examination in October 1935 revealed an enlargement of the whole of the metacarpal of the thumb. It was twice its normal size. Tenderness was rather marked. Movement was limited and moderately painful at the carpometacarpal and metacarpophalangeal joints. The Wassermann reaction was positive, four plus.

Roentgenographic examination (Fig. 1) showed extensive involvement of the whole of the metacarpal bone. Its original outline was almost entirely lost in a pathological process which had produced multiple small areas of destruction, superimposed upon which was a great amount of new bone laid down irregularly beneath the periosteum. There were no radiating spicules and no uniform layers of subperiosteal bone.

As diagnosis was uncertain, a biopsy was performed. This revealed a tuberculous inflammatory reaction.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 13, 1936.

The diagnosis in this case was difficult and uncertain. Physical and roentgenographic examinations suggested bone tumor or low-grade osteomyelitis. For bone tumor, the roentgenogram suggested Ewing's endothelioma, because of the multiple small areas of bone destruction and the irregular masses of new bone. Against such a diagnosis was the age of the patient, the bone involved, and the absence of roentgenographic changes indisputably characteristic of Ewing's endothelioma. Against osteomyelitis (pyogenic, tuberculous, or syphilitic) was the absence of marked evidences of inflammation or of pus. The critical feature lay in the history of earlier tuberculosis.

Physical examination in characteristic cases can yield facts of the utmost importance, upon which an accurate diagnosis of tumor and of the type of tumor can often be made. The age of the patient, the bone involved, the situation of the tumor in the involved bone, and the characteristics of the tumor itself are factors which, when taken together, may constitute a clear-cut clinical picture. Real difficulties arise when the tumor occurs in an unusual situation. Here many of the distinctive features are lost and the history, as well as the clinical examination, does little more than suggest a malignant lesion. These remarks refer, of course, to the

FIG. 1

Case 1. Roentgenographic appearance of destructive and productive lesion of the metacarpal bone of the right thumb, somewhat resembling Ewing's tumor. Biopsy proved the lesion to be tuberculous. This case illustrates the value of the case history in diagnosis of a bone tumor; this patient had previously suffered from tuberculosis.

early diagnosis of bone tumors. In their later stages their nature is only too obvious.

Good roentgenograms are of the utmost value in reaching a diagnosis of bone tumor and in establishing its exact nature. The progress made in the knowledge of bone tumors would not have been possible without the aid of the roentgenogram. It is the most important single agent for diagnosis at our disposal. Careful and critical analysis will yield much information.

Even the roentgenogram has its limitations. What it can reveal with absolute fidelity are the changes produced in a bone by the presence in it of a malignant tumor. There is nothing in the roentgenogram which is pathognomonic of the particular tumor cell which is causing the changes in its host. Certain tumors commonly give rise to changes which recur with sufficient frequency to lead us to feel that such changes are distinctive, but this evidence is not quite trustworthy. Exceptions occur which make it impossible to say that such and such a roentgenographic appearance always means such and such a bone tumor. The value of the roentgenogram lies in the perfect fidelity with which it reproduces bone changes, including the formation of such new bone as may come from the tumor. Careful observation and sound deduction add much to the knowledge obtainable from the roentgenogram.

We naturally rely greatly upon the roentgenogram as the most important agent in reaching a diagnosis. So revealing is it of changes in bone that often we place too much reliance upon it. The following cases indicate this difficulty:

CASE 2. I. S., a female, fourteen years of age, while standing on her head in July 1933, experienced a pain in her neck. It continued for four or five days and was accompanied by stiffness. Ultimately it disappeared. A month later she tripped on a stump and fell. When she got up, she walked with difficulty, but she managed to get home. The next morning her legs were completely paralyzed, and two days later her arms also became paralyzed and she became incontinent. The history was otherwise irrelevant.

Examination showed complete paralysis and anaesthesia below the level of the fourth cervical segment except for feeble movement in the left fingers. There was incontinence of urine and faeces. A roentgenogram (Fig. 2) showed a destructive lesion of the fifth cervical vertebral body with marked collapse.

It happened that shortly before this, the author had seen a male, aged thirty-five, with a similar lesion. As he was cranking his car, the crank handle slipped from the shaft and his effort straightened out his trunk with a snap. There was immediate pain in the neck and a roentgenogram (Fig. 3) revealed a pathological compression fracture of the body of the fourth cervical vertebra. Symptoms of cord pressure were mild. A clinical and roentgenographic diagnosis of giant-cell tumor was made. Treatment by fixation and x-ray resulted in marked improvement so that the patient was able to leave the hospital. On the first day that he returned to work he had the misfortune to be thrown from his milk wagon to the pavement, sustaining a fractured skull from which he died. A post-mortem examination was made and the cervical spine was removed. This revealed a giant-cell tumor.

With such a case as a recent memory, it was not unnatural that the author should regard this child's lesion as a giant-cell tumor also. Paraplegia was so complete that laminectomy was performed on August 4, 1933. This operation revealed replacement of

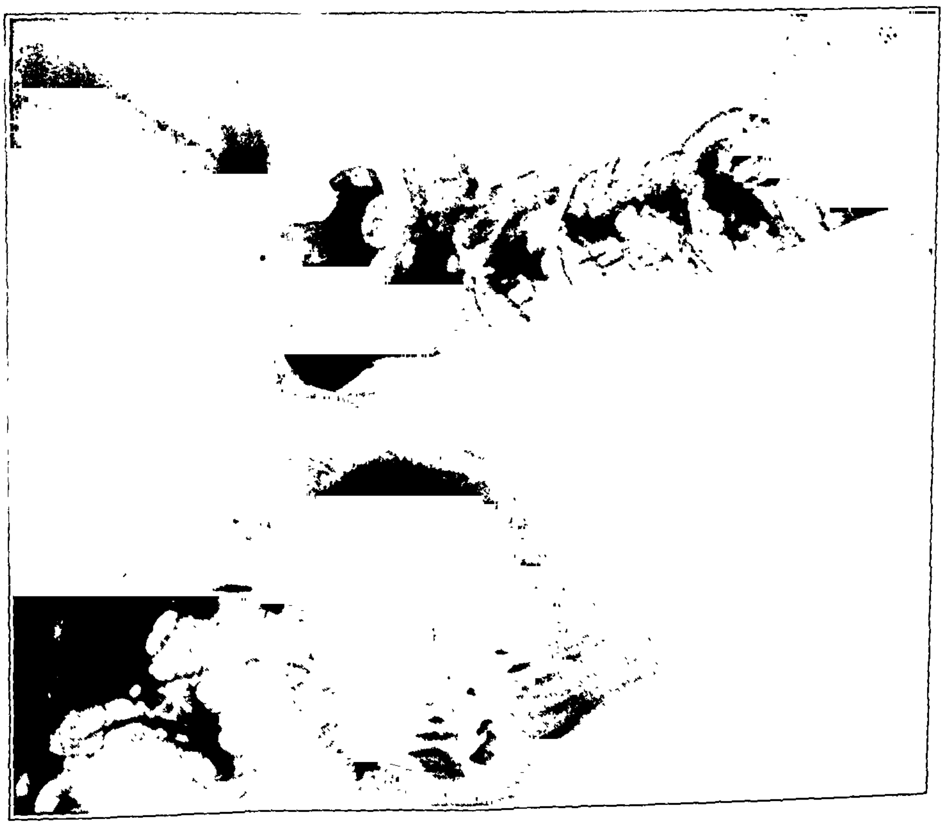

Fig. 2

Case 2. A destructive lesion of the body of the fifth cervical vertebra with collapse and paraplegia. Its course and the roentgenographic appearance so closely resembled a proved case of giant-cell tumor (Fig. 3) that this diagnosis was held to be correct until biopsy proved the lesion to be Ewing's tumor.

Fig. 3

A proved case of giant-cell tumor of the third cervical vertebra. The history, physical findings, and x-ray appearance so closely resembled those of Case 2 (Fig. 2) that accurate distinction was possible only by biopsy.

the spinous process and lamina of the fifth cervical vertebra by a tumor. Frozen section ruled out giant-cell tumor and suggested myeloma, but paraffin section proved the tumor to be Ewing's endothelioma. This diagnosis was confirmed by the Registry of Bone Sarcoma (Case No. 1590). No improvement followed operation. The patient died eleven months later. There was great extension of the tumor locally and another similar tumor was apparent over the sacrum.

In this case the diagnosis could not be made except from section. The history and the physical examination indicated transverse-compression myelitis of the cervical cord. The roentgenogram so closely resembled a proved case of giant-cell tumor that this was the diagnosis which was made. Biopsy proved the tumor to be Ewing's endothelioma.

Case 3. A. W., a female, aged twenty-one years, in January 1935 commenced to experience pain in the right hip without any preceding trauma. The pain slowly increased and kept her awake at night. Jarring increased the pain. On admission in July 1935, she walked with a marked limp and presented limitation of movement of the hip joint to one-half the normal range. Muscle spasm was present as well as tenderness over the hip joint on pressure. There was atrophy of the thigh amounting to one inch.

A roentgenogram (Fig. 4) showed a destructive lesion of the neck of the femur without expansion of the cortex and without clearly defined outlines. A diagnosis of osteogenic sarcoma was made.

Biopsy, on July 13, 1935, revealed the typical gross and microscopic appearances of a giant-cell tumor. The tumor was cleanly removed by curettage, and the wound was closed tightly.

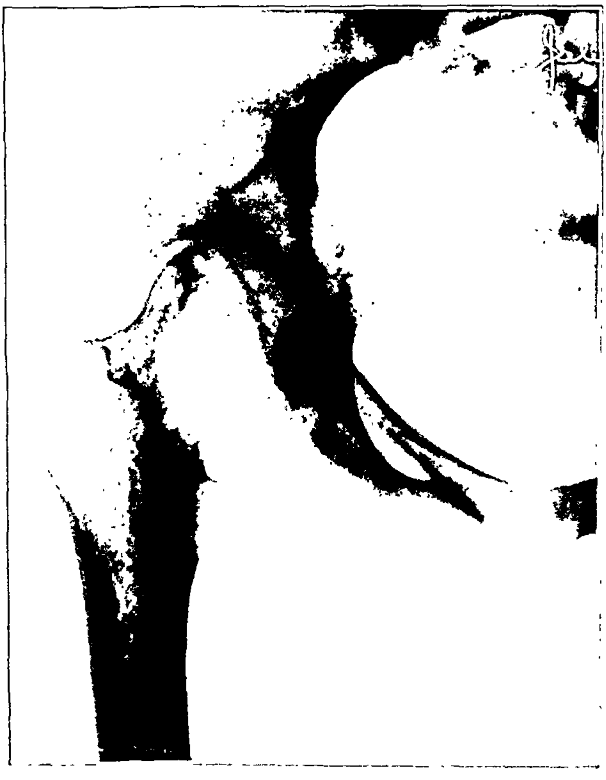

Fig. 4

Case 3. A giant-cell tumor of the neck of the femur which lacks the distinctive roentgenographic appearance. Accurate diagnosis was reached only by biopsy.

In this case the history and physical examination indicated only some lesion of uncertain nature in the hip joint. The roentgenogram showed the picture characteristic of osteolytic osteogenic sarcoma. Biopsy was the only measure which revealed the true nature of the tumor.

Case 4. R. F., a thirteen-year-old boy, was first seen in December 1932. Three months

prior to admission, soreness and tenderness on the outer side of the left leg had attracted attention to a swelling. Under treatment with iodine, the soreness and swelling was said to have diminished and for two months the patient had not been much disabled by it. During the two weeks prior to examination there had been recurrence of soreness, redness, and swelling. There was no history suggesting osteomyelitis.

Examination showed a healthy boy who walked without a limp. The upper half of the outer side of the left leg was swollen, tender, and red. The swelling was hard, in places bony hard, and centered about the fibula. The fibula seemed slightly longer than normal, so that the leg was distorted by angulation.

A roentgenogram (Fig. 5) showed what seemed to be a typical osteogenic sarcoma of the upper end of the fibula. Sun-ray spicules were particularly well marked, as well as the terminal subperiosteal wedge.

The leg was amputated on December 10, 1932, and the specimen was examined. Histologically the picture was that of Ewing's endothelioma. Dr. Ewing himself stated: "The sections show a rather typical endothelioma." The majority of opinions expressed by the Registry of Bone Sarcoma (Case No. 1456) were in favor of Ewing's tumor.

The patient is still alive and well, three years following operation.

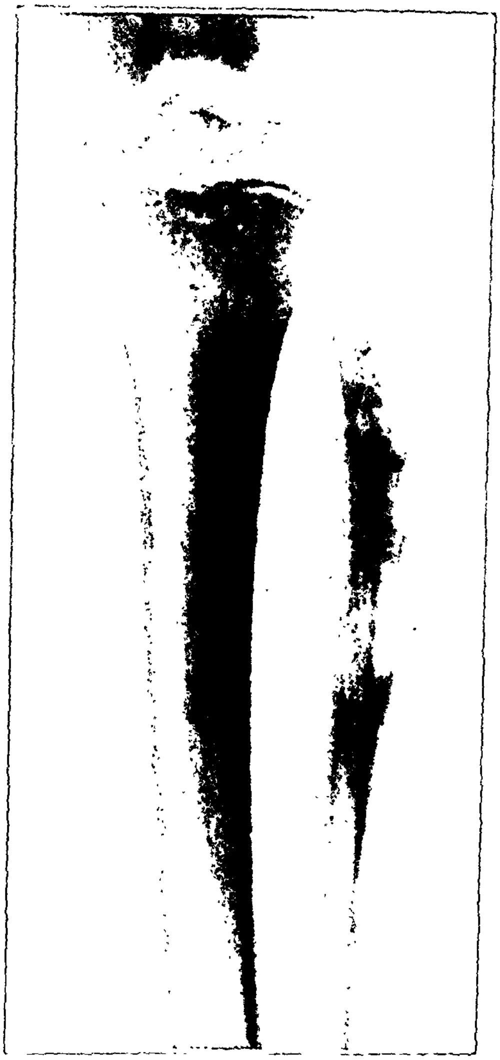

FIG. 5

Case 4. A case of Ewing's tumor which presented the x-ray appearance of osteogenic sarcoma with especially well-marked sun rays. Accurate diagnosis was reached only after section following amputation.

This case well illustrates how misleading a roentgenogram can be. The situation of the tumor and the position and type of the new bone formed seemed characteristic of osteogenic sarcoma. The histological section alone revealed the true nature of the tumor.

CASE 5. A. M., a male, aged twenty-one years, in August 1935, while standing at the edge of the lake preparatory to plunging in, raised his arms above his head to dive. As he did so, he experienced a sharp pain in the right shoulder. He was unable to use his arm and this disability continued until his operation in October 1935.

Eight years previously, while in a hospital for an acute mastoiditis, the patient had had some trouble with this shoulder and a roentgenogram had been taken. He was told that a cystic condition was present, but, because of the acute infection, it was felt unwise to do anything about it at that time. The acute mastoiditis was followed by suppurating glands in the neck. The course which they followed suggests they may have been tuberculous glands. Since the occasion eight years previously, when the lesion in the shoulder had been diagnosed by roentgenographic examination, from time to time the patient had experienced clicking and pain. Nevertheless he had led an active and particularly athletic life.

Examination in October 1935 showed the right arm held to the side by muscle spasm. Crepitus was present on movement. A roentgenogram (Fig. 6) showed a picture typical of benign giant-cell tumor.

On October 11, 1935, a biopsy was performed. The lesion was a cavernous space in the head of the humerus, lined with dense fibrous tissue and containing in its center yellowish, firm, custardlike material. Frozen section revealed the lesion to be tuberculous. A second frozen section yielded the same diagnosis. The material filling the space was carefully removed with a curette and the wound was packed with iodoform gauze.

Tubercle bacilli were subsequently recovered by guinea-pig inoculation and on culture.

There was nothing in the history of this patient to suggest that he had tuberculosis of the shoulder. The story of his recent disablement was typical of a pathological fracture which was indeed present in the roentgenogram. The roentgenographic appearance was typical of giant-cell tumor and most atypical of tuberculosis. Only the frozen section and the subsequent recovery of tubercle bacilli made possible an accurate diagnosis.

Experiences such as these and many others have led the author to feel that a biopsy forms an important part of the examination of a case of bone tumor. The number of cases in which clinical and roentgenographic diagnoses have been changed by histological section is considerable, amply sufficient to make one feel that biopsy should always be performed in any case of doubt.

Fig. 6

Case 5. Tuberculosis of the head of the humerus presenting the roentgenographic appearance of giant-cell tumor. Biopsy revealed the true nature of the lesion and tubercle bacilli were recovered on guinea-pig inoculation.

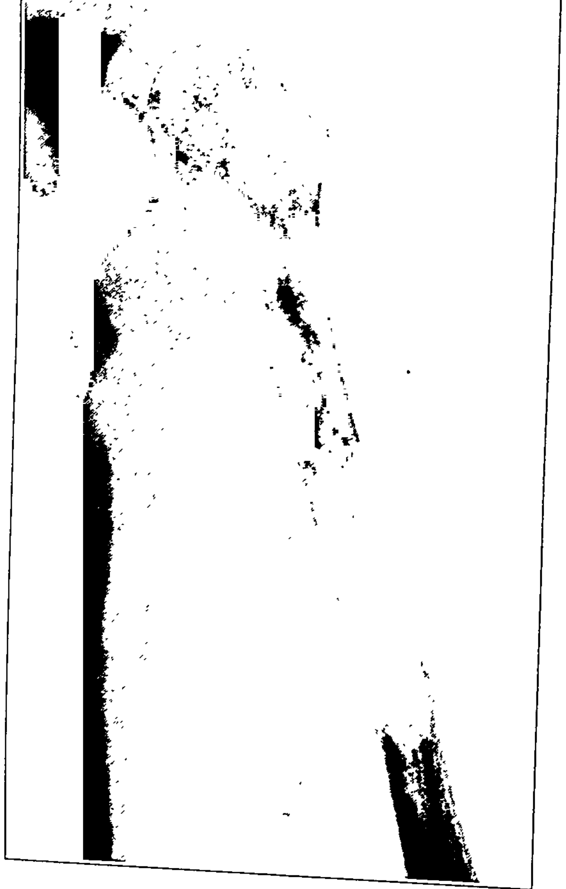

Fig. 7

Case 6. An atypical destructive lesion of the center of the shaft of the humerus with pathological fracture. Because of its resemblance to Fig. 8, it was believed to be an atypical giant-cell tumor.

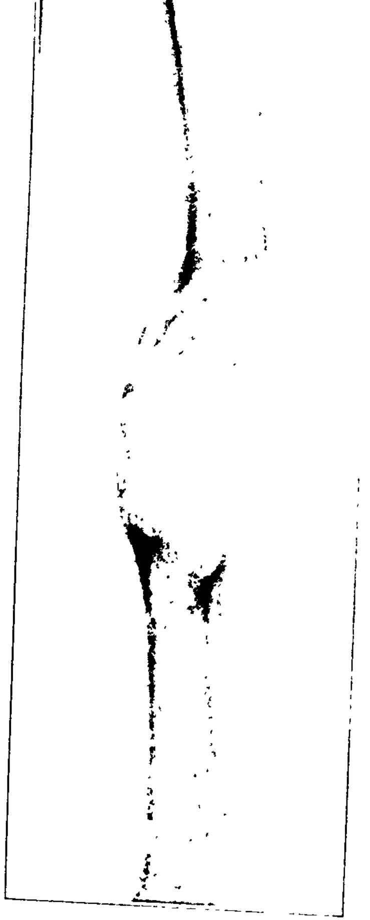

Fig. 8

In this case the lesion, the x-ray of which closely resembles Fig. 7, proved to be a giant-cell tumor with malignant propensities. Local recurrence after resection necessitated amputation.

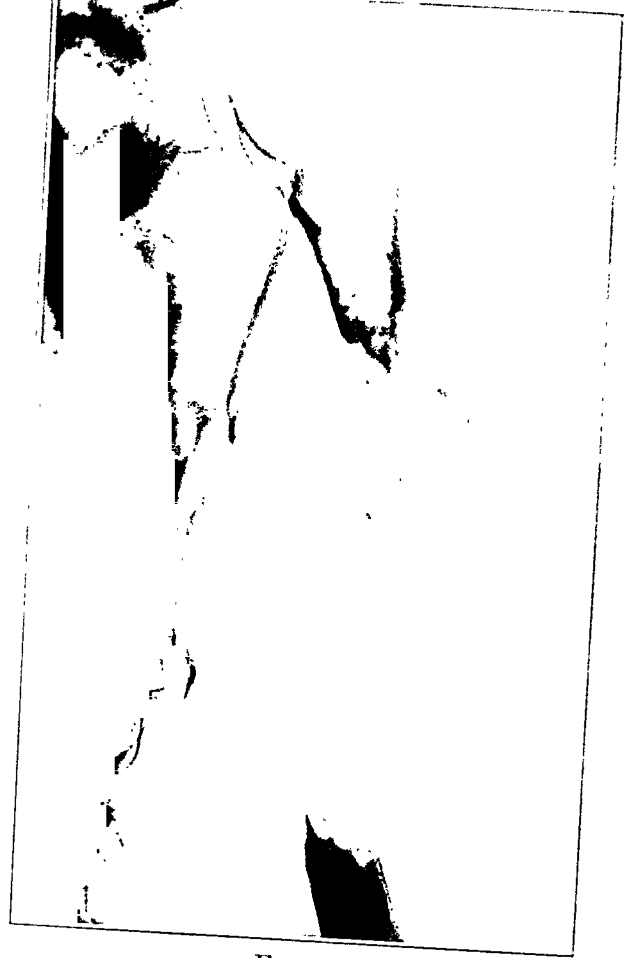

Fig. 9

Case 6. Roentgenogram showing how the destruction of the humerus (Fig. 7) had progressed in eight months. Diagnosis made from biopsy was osteogenic sarcoma (Registry of Bone Sarcoma, Case No. 1430). No recurrence four years after amputation.

The author is well aware of the objections which may be raised against biopsy. There will be constantly advanced the possibility of disseminating the disease by cutting into the tumor. This may be true, although the writer is not convinced by the evidence which is advanced. Certainly those tumors upon which biopsy is not performed metastasize frequently and early, and, in the author's experience, as readily as do any tumors which have been examined. The great advantages of biopsy should not be discarded for an unproved fear.

A more serious objection is the difficulty which the pathologist may have in reaching a diagnosis even when he has the tissues under the microscope. This is a very real difficulty to which sufficient appreciation is not given. It can be illustrated by the following case.

Case 6. Mrs. M. B., aged twenty years, sustained a fracture of the left humerus in March 1932. The injury was a trivial one and roentgenographic examination showed that the fracture had occurred through an area of bone destruction,—a pathological fracture. In spite of this, the fracture was treated by fixation in plaster. Three months later there was complete non-union and a roentgenogram (Fig. 7) showed absorption of two inches of the middle of the shaft of the humerus. There was evidence of expansion of the cortex of the shaft. The roentgenogram did not resemble any of the usual pictures of bone tumor.

Shortly before this, the author had seen a man with a similar destructive lesion in the middle of the shaft of the humerus. The roentgenogram (Fig. 8) presented many of the features characteristic of giant-cell tumor—expansion of cortex, clearly defined outline, and trabeculation—but the situation was unusual. Biopsy revealed the typical histology of a giant-cell tumor. Local resection with reconstruction of the humerus was performed. A recurrence in soft tissues, which did not respond to x-ray treatment, necessitated amputation of his arm.

Such an experience led the writer to feel that he was dealing again with an atypical giant-cell tumor. Biopsy was performed on May 30, 1932. The tissue was reported upon by Dr. W. L. Robinson as osteogenic sarcoma. In the gross, the tumor proved cystic; the walls consisted of yellow tissue. Dr. James Ewing saw this patient and the biopsy material. He expressed the opinion that the tumor was not essentially malignant and advised a local resection of the tumor. In the meantime there had been rapid increase in the destruction of the shaft of the humerus, as shown by the roentgenogram (Fig. 9). The fluid in the cyst accumulated rapidly and under tension. Aspiration of this fluid was undertaken to relieve the patient's discomfort. Finally, aspiration had to be performed daily.

On December 12, 1932, an attempt was made to perform a local resection of the tumor. Difficulties from hemorrhage resulted in injury to the brachial artery, which compromised the blood supply to the arm, and gangrene supervened. On December 16, 1932, the arm was removed by disarticulation at the shoulder.

The material submitted to the Registry of Bone Sarcoma (Case No. 1430) is reported upon as osteogenic sarcoma. The patient is alive and well four years after the onset of her symptoms.

Some of the pathologist's difficulties can be removed by providing him with an adequate amount of tissue to examine. For this reason the author is not very favorably impressed with punch biopsies. In the most difficult cases it is asking too much of the pathologist to express an opinion on so small an amount of tissue.

A further objection to biopsy arises in those cases which are being

cared for at centers where a skilled pathologist is not available. An inadequate pathological opinion is worse than none at all.

In spite of these weighty objections, it is felt that the advantages of biopsy are so great that it should be used frequently. Indeed, in the last three years, it has been the author's custom to perform a biopsy in every case of bone tumor. So far there has been no cause to regret this policy.

SUMMARY

Difficulties in the diagnosis of bone tumors frequently arise. The history and physical examination are often inconclusive. Even the roentgenographic examination may be of uncertain value or definitely misleading. Biopsy is by far the most reliable aid to diagnosis and should be resorted to frequently, with due appreciation of its limitations.

FROZEN-SECTION DIAGNOSIS OF TUBERCULOUS JOINTS

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The difficulty of making an accurate diagnosis of joint lesions from the clinical findings, roentgenograms, and usual laboratory tests is becoming more generally recognized by orthopaedic surgeons. Also, the necessity for establishing the correct diagnosis before instituting treatment, particularly in those cases in which tuberculosis is in any way suspected, is becoming more apparent, simply because the forms of treatment applicable to the various diseases are so different.

For these reasons it has been the practice for some years at the New York Orthopaedic Dispensary and Hospital to perform an exploratory operation on those bone and joint lesions in which tuberculosis may be the etiological factor, and to attempt to establish the diagnosis during the operation by microscopic examination of frozen sections. Thus, if tuberculosis is proved, a fusion operation may be performed at once; if tuberculosis is not found, whatever other procedure (if any) is indicated may be carried out with considerable confidence that the right diagnosis is known.

In order to determine the degree of accuracy which may be expected in diagnoses made from the frozen sections of fresh tissue, the following study has been made of 175 such exploratory operations which were done at the New York Orthopaedic Hospital during the years 1928 to 1934 inclusive.

ACCURACY OF PREOPERATIVE DIAGNOSES

The first analysis was made to find how often the preoperative diagnosis was correct when checked with the final pathological diagnosis. It should be stated that the clinical and roentgenographic diagnoses were taken from the hospital charts and in some cases there was difficulty in deciding just what the respective diagnoses were, so that the figures may be subject to some small error.

In 145 of the total 175 cases the clinical diagnosis agreed with the roentgenographic interpretation and was found to be correct 116 times, or 80 per cent. There were twenty-four cases in which the clinical diagnosis disagreed with the roentgenographic reading, and in this group the clinical diagnosis was correct only eleven times, or 45.8 per cent. In a third group of six cases no roentgenographic study had been made and here the clinical diagnosis was correct three times, or 50 per cent.

In other words, the preoperative clinical diagnosis of 175 carefully studied cases of bone and joint lesions was corroborated by the final pathological diagnosis 130 times, or 74.2 per cent. Therefore, it is important to remember that there is at least a 25-per-cent. chance of error in considering the preoperative diagnosis of such lesions.

SITE OF EXPLORATORY OPERATIONS

The disease for which the exploratory operations were performed involved the following regions: knee joint, sixty-eight cases; hip joint, fifty-two; ankle joint, fifteen; shaft of long bone, nine; tarsal joint, eight; wrist joint, seven; tendon sheath, six; shoulder joint, three; elbow joint, three; sacro-iliac joint, two; and metatarsophalangeal joint, two. The location of the lesion did not seem to have any effect on the accuracy of the frozen-section diagnosis, nor did the age of the patients, the youngest of whom was one year old and the oldest sixty-four. However, there was a certain significance in the duration of the disease, as will be indicated later.

AGREEMENT OF FROZEN-SECTION AND PARAFFIN-SECTION DIAGNOSES

It was important to find out how many times the frozen-section diagnosis agreed with the paraffin-section diagnosis, whether or not the latter proved to be the final diagnosis. As expressed in Table I, it was noted that there was agreement in 147, or 84 per cent., of the 175 cases, and that in twenty-eight, or 16 per cent., the paraffin-section diagnosis did not substantiate the frozen-section diagnosis.

TABLE I

AGREEMENT OF FROZEN-SECTION AND PARAFFIN-SECTION DIAGNOSES

Diagnoses	No. of Cases	Per Cent.
Agreement:		
Both diagnoses: Tuberculosis	90	
Both diagnoses: Chronic inflammation	54	
Both diagnoses: Syphilis	1	
Both diagnoses: Giant-cell tumor	1	
Both diagnoses: Acute inflammation	1	
Total	147	84.0
Disagreement:		
Frozen section: Chronic inflammation; Paraffin section: Tuberculosis	23	
Frozen section: Tuberculosis; Paraffin section: Chronic inflammation	5	
Total	28	16.0

There is no comment necessary on the first half of Table I except to say that, in three of the cases diagnosed as chronic inflammation by both sections, guinea-pig inoculation proved tuberculosis to have been present in two, and the third case was proved to be tuberculous at a later operation. In these cases the joints had been diseased for a long time and much scar tissue had formed around them. Undoubtedly the tissue taken for sectioning was outside of the actually diseased area.

The disagreement in diagnoses, as shown in the second half of Table I, is more important. Of the twenty-three cases proved to be tuberculous by paraffin sections, but not by frozen sections, twenty had been diagnosed as tuberculous before operation. In these cases the location of the disease was as follows: hips, fourteen; knees, five; and wrist, one. Although the diagnosis was confirmed in only twelve cases by guinea-pig inoculation, there was no doubt that the diagnosis of tuberculosis was correct. The remaining three cases had been thought to be non-tuberculous before operation, but were proved to be tuberculous by the paraffin sections and the guinea-pig inoculations.

Of the five cases in which the frozen-section diagnosis was tuberculosis, not confirmed by the paraffin sections, all had negative guinea-pig inoculations, and their subsequent course left little doubt that the frozen-section diagnosis was wrong. This is a serious error, and it is clear that, unless the frozen sections demonstrate unmistakable tuberculosis, the pathologist should report only chronic inflammation. The slides of four of these cases have been saved and on further study are thought not to show sufficient evidence for the diagnosis of tuberculosis to have been made.

GUINEA-PIG CORROBORATION OF DIAGNOSIS

Although the histological picture of tuberculosis is a definite one, there is the possibility of faulty interpretation or selection of tissue, and so an attempt to corroborate the section diagnosis by an inoculation of two guinea pigs with pus or tissue from the operative field should always be made.

An analysis of the results of the guinea-pig inoculations in this series showed that there were 133 such tests done, the result corroborating the tissue diagnosis 113 times, or 85 per cent. The diagnosis was not corroborated by eleven guinea-pig tests, and in nine cases the animals died of an intercurrent infection too soon for results to be obtained. It is clear that this method of diagnosis, although important and of a high degree of accuracy, is open to a certain percentage of error and calls for careful selection by the surgeon of tissue for pathological study. Two cases, in which the guinea-pig inoculation proved tuberculosis to be present after the reports of both sections had given the diagnosis of chronic inflammation, have already been mentioned as having old, badly scarred lesions.

COMPLETE ANALYSIS OF FROZEN-SECTION DIAGNOSES

The analysis of the results of the frozen-section diagnoses in the 175 exploratory operations is given in Table II. Under Group A it will be seen that when the clinical diagnosis was tuberculosis, whether or not the roentgenographic interpretation agreed, the frozen section proved the diagnosis in 80 per cent. of 130 cases. When the clinical diagnosis was not tuberculosis, with or without roentgenographic support, the frozen-section diagnosis agreed with the final diagnosis in 89 per cent. of thirty-

TABLE II

COMPARISON OF PREOPERATIVE DIAGNOSES WITH PARAFFIN SECTIONS, FROZEN SECTIONS, AND FINAL DIAGNOSES

Group	Preoperative Diagnoses		Final Diagnosis	Total No. of Cases	Paraffin Section Agreed with Final Diagnosis	Frozen Section Agreed with Final Diagnosis	
	Clinical	Roentgenographic			*No. of Cases*	*No. of Cases*	*Per Cent.*
A	Tuberculosis	Tuberculosis	Tuberculosis	91	88	72	79.1
	Tuberculosis	Not tuberculosis	Tuberculosis	10	10	7	70.0
	Tuberculosis	Tuberculosis	Not tuberculosis	18	18	14	77.7
	Tuberculosis	Not tuberculosis	Not tuberculosis	11	11	11	100.0
Total for Group A				130	127	104	80.0
B	Not tuberculosis	Not tuberculosis	Not tuberculosis	25	25	25	100.0
	Not tuberculosis	Tuberculosis	Not tuberculosis	1	1	1	100.0
	Not tuberculosis	Not tuberculosis	Tuberculosis	11	11	8	72.7
	Not tuberculosis	Tuberculosis	Tuberculosis	2	2	1	50.0
Total for Group B				39	39	35	89.7
C	Tuberculosis	None	Tuberculosis	2	2	2	100.0
	Tuberculosis	None	Not tuberculosis	3	3	2	66.6
	Not tuberculosis	None	Tuberculosis	0	0	0	0.0
	Not tuberculosis	None	Not tuberculosis	1	1	1	100.0
Total for Group C				6	6	5	83.3
Total for Entire Series				175	172	144	82.2

nine cases. When there was no roentgenographic study, the frozen-section diagnosis was correct in 83 per cent. of six cases. A study of this table with the various contradictions of preoperative and pathological diagnoses will serve to emphasize again the inherent difficulty of making an accurate clinical diagnosis of joint lesions.

PREOPERATIVE DIAGNOSES PROVED WRONG

Besides confirming a preoperative diagnosis, frozen sections have been found of great value in showing the clinical diagnosis to have been wrong, and this has meant disproving a suspected tuberculous lesion, as well as proving tuberculosis to be present when it was not expected.

There were thirty-two patients with a preoperative diagnosis of tuberculosis who were proved, finally, to have some other disease, and in twenty-seven, or 84 per cent., the frozen-section diagnosis of chronic inflammation was correct. The other five cases were those which have been mentioned earlier as having been diagnosed as tuberculosis from frozen sections which showed insufficient evidence. The possibility of this error must be stressed, but it is an error which certainly should not occur if the rule is strictly followed of not diagnosing tuberculosis from frozen sections unless the histological picture is unmistakable.

In the case of thirteen other patients, who were thought before operation to have conditions other than tuberculosis—such as chronic infectious arthritis, coxa plana, osteomyelitis or tumor—the diagnosis had to be changed to tuberculosis. This was an interesting group and in nine, or 69 per cent., the frozen-section diagnosis was tuberculosis and was correct, the other four being considered doubtful and therefore called chronic inflammation at the time of the operation.

Thus it may be seen that, of forty-five cases for which a final diagnosis was established differing from the preoperative clinical diagnosis, a correct interpretation was made from the frozen sections in thirty-six, or 80 per cent.

COMPARISON OF FROZEN-SECTION DIAGNOSES WITH FINAL DIAGNOSES

The last criterion for judging the accuracy of frozen-section diagnoses and establishing their value to the surgeon at the operating table is the actual number of times that there may be expected to be agreement with the final diagnosis made after all the evidence has been collected and considered.

The results of this series of examinations are given in Table III, and it is found that when the final diagnosis was tuberculosis the frozen-section diagnosis was correct in 77 per cent. of 116 cases. When there was a final diagnosis other than tuberculosis, the frozen sections gave the right diagnosis in 91 per cent. of fifty-nine cases. In other words, there was an average of 82 per cent. of correct diagnoses made by examination of frozen sections during 175 exploratory operations.

TABLE III

COMPARISON OF FROZEN-SECTION DIAGNOSIS WITH FINAL DIAGNOSIS

Final Diagnosis	Total No. of Cases	Frozen Section Agreed with Final Diagnosis	
		No. of Cases	*Per Cent.*
Tuberculosis	116	90	77.5
Not tuberculosis	59	54	91.5
Total	175	144	82.2

DISCUSSION

The success of frozen-section diagnosis on fresh tissue during exploratory operations depends on three things. In the first place, the surgeon, with the help of the pathologist, must choose satisfactory tissue for sectioning. Random removal of specimens without regard for their gross appearance of disease, particularly in lesions showing a good deal of fibrous-tissue replacement, will surely increase the percentage of failures.

In the second place, the technique of preparing the sections must be satisfactory. Practically all the sections made in these cases were attached to a glass slide after sectioning and then stained with hematoxylin and eosin. The extra five minutes required by this method is compensated by the two advantages of giving a more familiar histological picture and of being permanent, so that the slides may be saved for future study and comparison. Some inflammatory tissues will not cut satisfactorily until after they have been embedded in paraffin and in these cases important parts of the specimen may never be seen in the frozen preparations and the real pathology will be missed. This source of error may be obviated in such cases only by the greatest care and patience in cutting and manipulating the sections.

In the third place, the interpretation of the slides is important and here the main fact to be emphasized is that no tissue should be called tuberculous when there is any ground for reasonable doubt.

Granting that these three requirements are fulfilled, it seems fair to believe, after this study, that the diagnosis made from frozen sections of fresh tissue may be considered correct in 82 per cent. of the cases.

It remains the responsibility of the operating surgeon to decide in the particular case whether or not it falls into the group of 82-per cent. right diagnoses or into the group of 18-per cent. wrong diagnoses. This he must do from his knowledge of all the factors in the clinical history and examination and from his opinion of the gross pathology. A report from the laboratory that the disease is tuberculosis, or, on the other hand, that tuberculosis is not found, should be helpful in making his decision, even

though he may have to conclude that it is necessary to wait longer before being certain of the correct diagnosis.

SUMMARY

1. In a study of the frozen-section diagnoses of 175 exploratory operations on lesions suspected of being tuberculous, the clinical preoperative diagnosis was found to be correct in 74 per cent. of the cases.

2. The frozen-section diagnosis agreed with the paraffin-section diagnosis in 84 per cent. of the cases.

3. Guinea-pig inoculation corroborated the diagnosis in 84 per cent. of the cases.

4. Of thirty-two cases thought to be tuberculous before operation, but proved by sections not to be, the frozen-section diagnosis was correct in 84 per cent.

5. Of thirteen cases thought not to be tuberculous before operation, but later proved tuberculous, the frozen-section diagnosis was correct in 69 per cent.

6. Of the 175 cases, 116 had a final diagnosis of tuberculosis and the frozen-section diagnosis had been the same in 77.5 per cent; fifty-nine cases had a final diagnosis other than tuberculosis and in these the frozen-section diagnosis had been right in 91.5 per cent.

7. Of the 175 cases, the frozen-section diagnosis agreed with the final diagnosis in 82 per cent.

OSTEOCAMP FOR OSTEOTOMOCLASIS

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The correction of deformities of bones by osteotomoclasis—simple osteotomy with immediate bending at the site of osteotomy—is occasionally a difficult procedure, even in such favorable locations as the supracondylar region of the femur, due to the tension of surrounding muscular and fibrous structures.

Usually, when the bowing deformity is marked and in locations where soft-tissue structures act as a bowstring, correction by means of simple osteotomy is impossible and wedge osteotomy with removal of a section of bone is necessary. (See Figure 1, *2*.) This decreases the length of an extremity which usually is already short.

For some time the author has felt that osteotomy and the application of an apparatus for gradual correction would permit the stretching of the soft tissues and correction of deformity without loss of length. This possibility has been made almost a certainty by the ease with which a tibia can be lengthened by well-planned and well-carried-out operative procedure.[1]

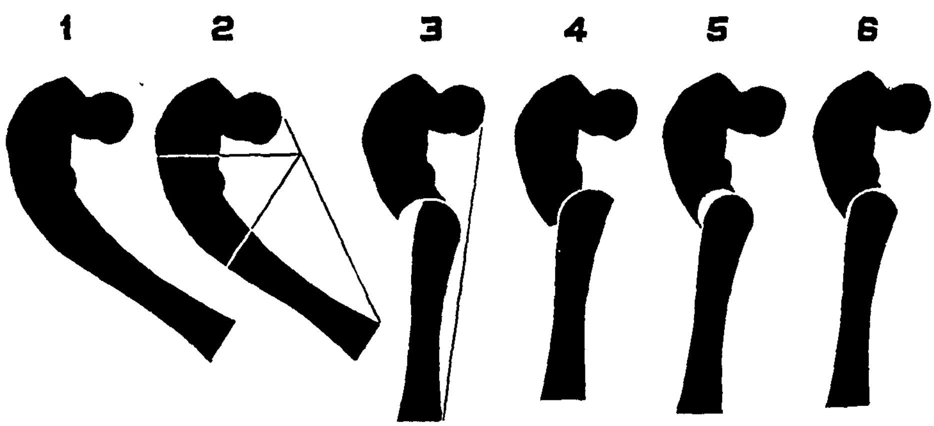

FIG. 1

Effect of different operative procedures to correct bowing deformity.
1: Outline tracing of roentgenogram of original condition;
2: Amount of bone resection necessary to correct position by wedging osteotomy;
3: Defect left if center of curved cut were placed laterally;
4: Projection of fragment if center of cut were placed medially;
5: Gap left if diameter of cut were same as diameter of femur;
6: Optimum contact secured by a cut of a diameter much larger than the femur and centering the curve cut on the center of the femur.

Therefore, an apparatus has been devised for gradually straightening the femur following osteotomy, and this apparatus has been called an osteocamp, since the bowing of a bone is called osteocampsia.

The apparatus consists of hinged arms with a worm gear at the center, solidly fastened to one arm, and a thread, worked by a handle, included rigidly in the other arm. When the handle and thread are turned, the worm gear is driven around slowly, thus changing the angle of the two arms. Two complete units are necessary,—one in front and one in back of the bone. Pin holes are provided through the arms at intervals of one-half an inch for the insertion ot three-sixteenths-inch drill-steel pins, and set screws are placed opposite each pin hole to allow the pins to be locked rigidly in place.

The procedure described has been used in the following case:

A young woman, twenty-five years old, of good general bodily health, was seen at St. Luke's Hospital Clinic in the fall of 1932. The patient had fractured the upper right femur three times, at the ages of eight, ten, and eleven years. She had a very marked deformity of the right thigh, due to bowing through a fibrocystic area in the upper femur. With the hip in full abduction and the greater trochanter impinging on the ilium, the right knee lay across the left with the pelvis level. It was impossible for the patient to get her heel to the floor when standing, and the extremity was seven and one-half inches short as measured from the anterior-superior spine to the internal malleolus (Fig. 2, *A*). Genu valgus of 15 degrees was present. A diagnosis of osteitis fibrosa cystica was made, hyperparathyroidism being ruled out.

Roentgenograms showed a medial bowing of the upper half of the femur of 67 degrees and an added coxa vara deformity of the neck of the femur of about 18 degrees, making a total medial bowing of 85 degrees (Fig. 3, *A*).

The difficulties involved—the presence of fibrocystic change in the bone, multiple previous fractures, and danger of infection when working in the upper femoral region near the perineum—were all realized in advance, but the patient was so crippled that an attempt to improve her condition seemed justifiable.

Exact drawings of the femur were made, as shown by roentgenograms, and a curved osteotomy was decided upon in an attempt to

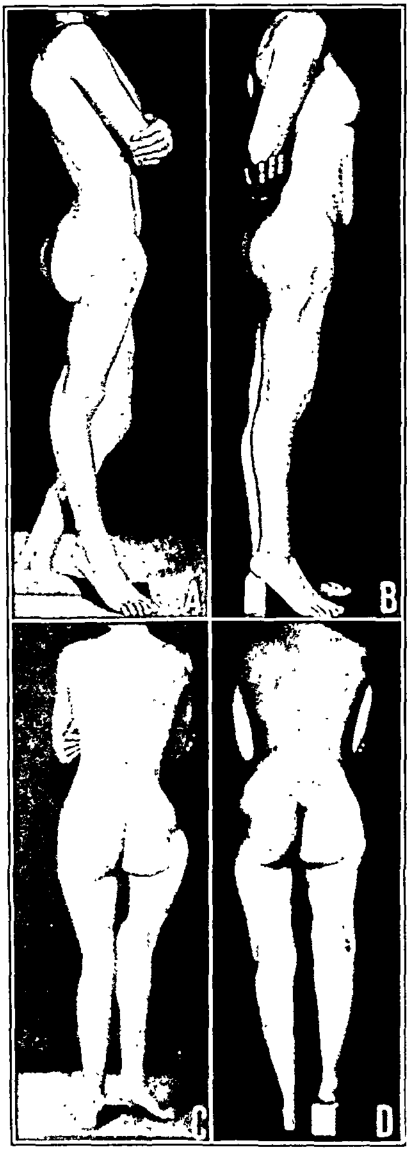

Fig. 2

Showing the amount of correction obtained by the method of osteotomoclasis described.

A and *C*: Original condition with marked lateral bowing and shortening of the thigh as well as anterior torsion, genu recurvatum, and genu valgus.

B and *D*: Correction of all deformities by straightening of the femur. The block beneath the heel is three inches in height.

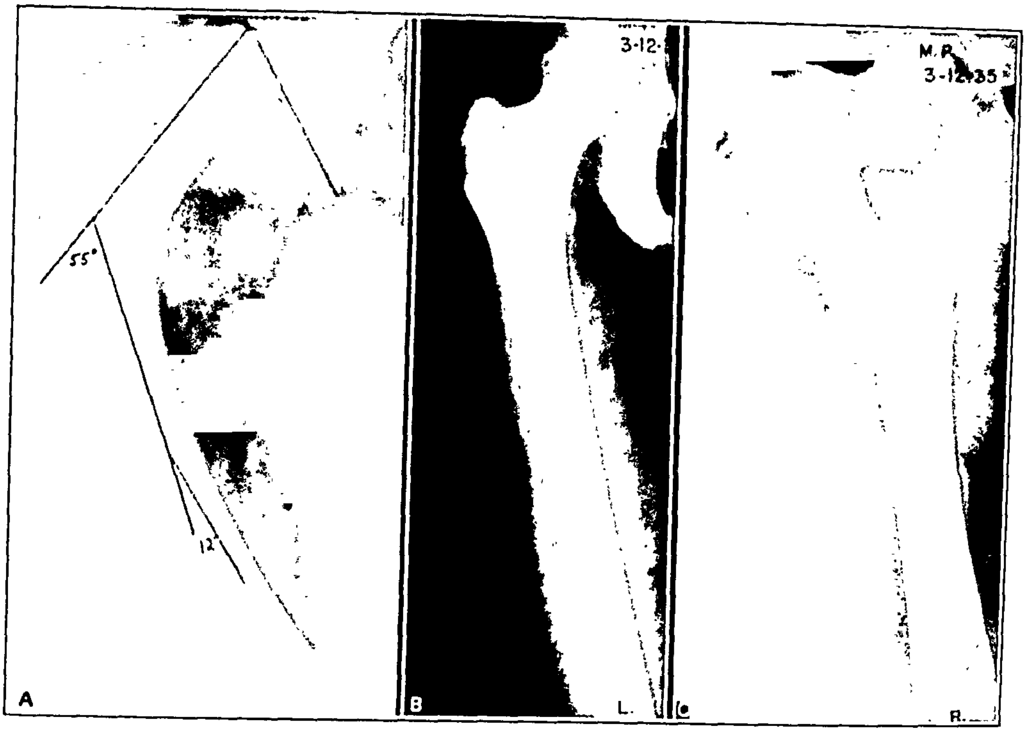

FIG. 3

Roentgenograms of femora, showing
A: Original condition of right femur;
B: Normal left femur;
C: Corrected right femur.

prevent displacement and allow rotation. It was found that the curve of the osteotomy would need to have a larger diameter than the width of the shaft of the femur to insure the best possible contact following correction and, furthermore, that the center of the osteotomy would need to be in the center of the femoral shaft and not toward either side, in order to give the best cosmetic result. (See Figure 1.) In order to make this curved osteotomy, a semicircular saw (Figs. 4 and 5) was manufactured which could be centered on a drill and which, when rotated back and forth a few degrees, would satisfactorily cut the desired curve.*

Operation, on November 18, 1932, consisted of a lateral incision through very adherent and extensive scar tissue which had resulted from previous operations. Due to the marked curve in the bone, the anterior muscular structures were easily displaced inward. A drill hole was placed at the center of the site selected for operation. The drill was then reversed into the socket of the saw and acted as a pivot to center the saw cut. This gave a curved osteotomy exactly as planned. All soft tissues were then retracted outward to their limits across the bone. Half of the apparatus was laid on the anterior surface of the thigh. This acted as a guide for the placing of two drill holes and two pins through the upper fragment and two drill holes and two pins through the lower fragment, with the center of the gear placed over the center of the osteotomy (Fig. 6).

The incision was sutured and sterile dressings were placed over it and over the point of emergence of the pins, both in front and in back. The halves of the apparatus were placed on the pins anteriorly and posteriorly and locked to the pins by the set screws. When this was done, the fragments were held rigidly in place and the leg could be handled freely without the necessity of any apparatus except the osteocamp. Sliding of the fragments on the pins was prevented by a sterile dressing and sterile felt rings slipped between the skin and the apparatus.

* Following the use of the saw in this case, apparatus for circular osteotomy was described by another surgeon, but the author has been unable to find the original article.

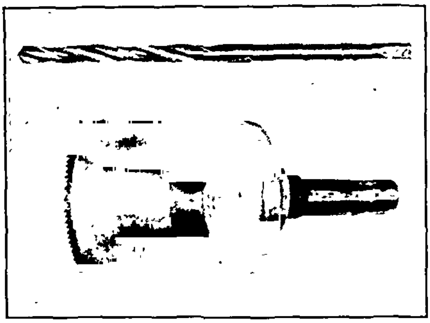

FIG. 4
Showing detail of drill and curved saw.

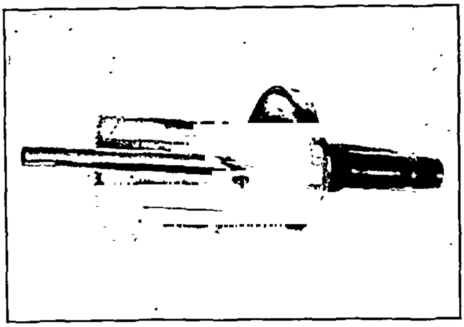

FIG. 5
Showing drill and saw as they would be inserted in the bit-stalk.

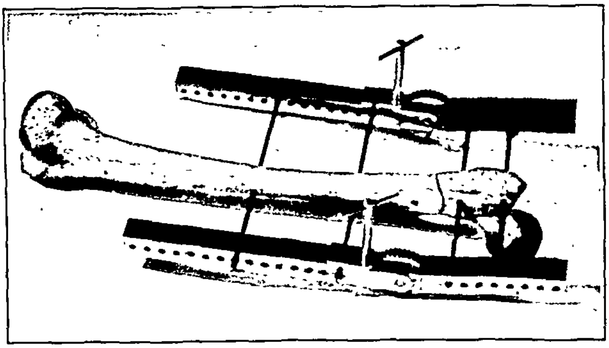

FIG. 6
Osteocamp set up on the femur, as in the case reported. Note the hole for centering and the curved osteotomy.

At the time of operation, a maximum stretching of about 10 degrees only could be secured, due to the tautness of the structures on the inner side of the thigh and the beginning bending of the three-sixteenths-inch drill-steel pins. Correction from 67 degrees to 9 degrees was complete in twenty-two days, a quarter of a turn giving about 2.5 degrees of correction each day.

Maceration of the scar tissue present from previous operations on the lateral surface of the femur took place to a moderate degree, and a hematoma drained through the posterior openings of the upper two pin holes.

The apparatus was removed and plaster was applied (Fig. 7-C) five weeks after the operation, and the cast was kept in place for six weeks. Following the removal of the cast, recurrence of the deformity through the soft callus occurred to the extent of 32 degrees within three weeks (Figs. 7-D, 7-E, and 7-F).

Manipulation under anaesthesia was done (definite soft union being found present) and a plaster spica was applied with the deformity at an angle of 9 degrees (Fig. 7-G). After union had taken place, there was slight absorption, so that four and one-half months later the osteotomy site had become solid at 1.5 degrees. All apparatus was removed at that time.

Infection of the fibrocystic bone at the point of maceration of the suture line in the original scar tissue required a local sequestrectomy a year later (Fig. 7-I). Since that time, there has been no further infection and the patient has been walking on the leg. She suffered a fracture of a fibrocystic patella by indirect violence in November 1934, but otherwise she has had no trouble. Supracondylar osteotomy for genu valgus has recently been done and the patient is walking without support and is greatly improved. Tibial lengthening to overcome some of the remaining shortening is planned.

This case is interesting as a study in reconstructive work. Several new procedures and bits of apparatus were planned out in advance and

successfully used. Such cases are rare, but other instances have occasionally been recorded in the literature.

FIG. 7-A FIG. 7-B FIG. 7-C

Figs. 7-A and 7-B: During straightening.
Fig. 7-C: In plaster following straightening. (Compare with Fig. 1, *6*.)

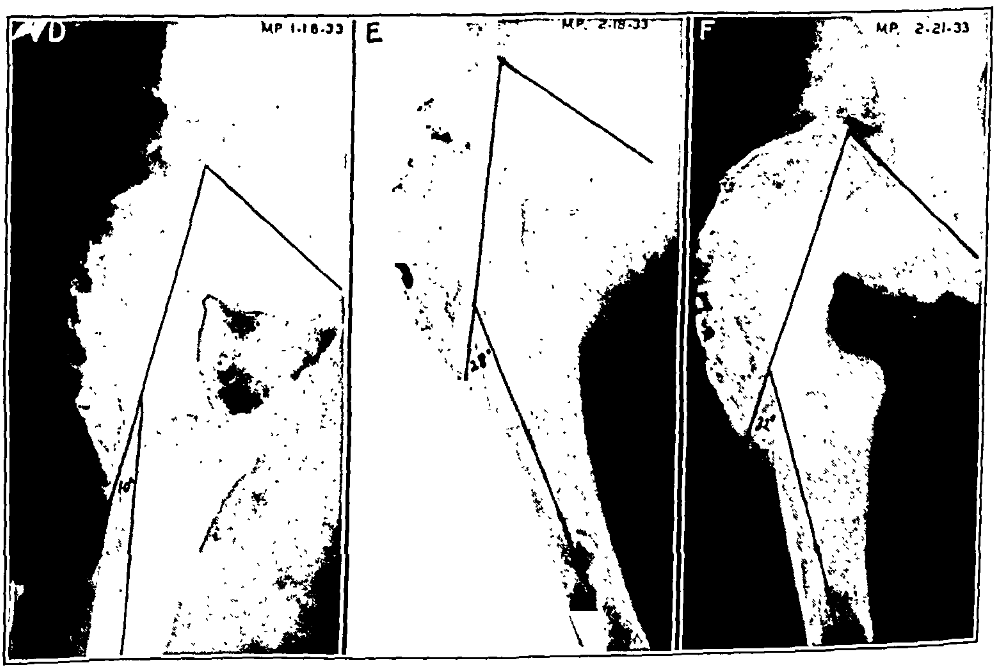

FIG. 7-D FIG. 7-E FIG. 7-F

Recurrence of deformity through soft callus.

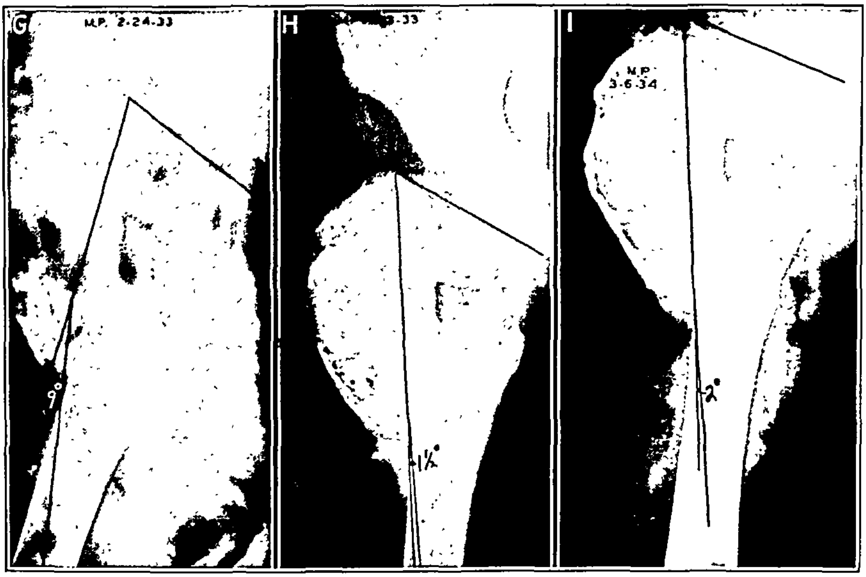

FIG. 7-G FIG. 7-H FIG. 7-I

Fig. 7-G: After manipulation and reduction of deformity.
Fig. 7-H: Following removal of all plaster; union solid but decalcified.
Fig. 7-I: Final result with solid union. There is a decrease in the fibrocystic changes, but a sequestrum is present in the lateral portion of the trochanteric fragment. This was later removed and healing took place.

It is hoped that other orthopaedic surgeons will be encouraged to undertake the reconstruction of similar cases rather than to consider them hopeless as in the past.

1. BOSWORTH, D. M.: Skeletal Distraction. Description of Apparatus. Surg. Gynec. Obstet., LII, 893, 1931.

SOME CONSIDERATIONS ON SUBTROCHANTERIC OSTEOTOMY AND INTRA-ARTICULAR ARTHRODESIS OF THE HIP JOINT

BY ERNST FREUND, M.D., F.A.C.S., VENICE, FLORIDA

A simple transverse osteotomy, if done technically well and according to right indications, is one of the most efficacious procedures in orthopaedic surgery. By this operation in well selected cases, a very beneficial change in the statics of the skeleton may be obtained and the function of the kinetic chain, of which the affected and deformed portion represents only a link, will become greatly improved. In children, because of the very active biological process which favors functional adaptation, the response to a well-healed corrective osteotomy will be almost immediate. Such patients are the best advertisers of our specialty. Lay people marvel at the quick restoration of or improvement in shape and function.

More complicated than the operative procedure is the indication for osteotomy. Besides the degree of disabling deformity, the duration of the deformity and the stage of the disease which caused it have to be taken into serious consideration. If performed too soon or too late after the onset of the disabling disease, an osteotomy may result within a very short time in a complete failure, despite an apparently excellent operative correction of the deformity. It is not sufficient to consider merely the actual amount of deformity which requires correction by osteotomy. The surgeon has to be well acquainted with the disease process underlying and causing the deformity, and he also is obliged to calculate the amount of adaptability of the organism to a change in its statics. The best osteotomy will be futile, if not perilous, if the patient's functional resources have been exhausted in the previous attempt to become adapted to the existing pathological position. Especially beyond the third decade of life, the readiness of the locomotor apparatus to compensate for alteration in form becomes considerably lessened.

In a case in which the deformity is of many years' duration, regardless of whether it is due to a primary joint or bone condition, one has to be very careful in contemplating a corrective osteotomy, especially if there are well established signs of a compensatory rearrangement of the kinetic chain with a satisfactory functional result. The lower extremity with its complicated task of weight-bearing and locomotion is for this reason of greater interest than the arm. Any deformity of the lower extremity will be reflected after a very short period of activity in the vertebral spine. Compensatory curves of the lumbar spine, and later on of higher levels, follow readily the shift or tilt of the pelvis, which is the invariable consequence of any change in the length of the limb, due either to position or to true deformity. This almost automatic readjustment to the best

possible efficiency represents one of the best examples of Payr's idea of a kinetic chain, in which the different links are tightly bound together and any little damage to one link immediately draws all the other portions of the system into participation.

The compensatory realignment is at first purely static and well controlled by muscle action. The pathological curvature of the spine disappears as soon as weight-bearing on the deformed extremity ceases. As time passes, however, the muscular adaptation has an increasingly greater effect upon the skeleton, and the compensatory curves become fixed. This means that a certain quiet physiological derangement has taken place in the complicated joint chain of the vertebral spine with some parts under more marked functional stress and others more or less in disuse. Anatomically this skeletal fixation expresses itself by very definite changes in the joint capsules of the intervertebral joints with shrinkage and thickening of the relaxed portions and comparative atrophy of the overstretched areas. Hand in hand with the changes in the capsular apparatus go structural transformations in the joint ends, especially in the cartilaginous layers of the joint surfaces. Atrophy of the joint cartilage with complete resorption from the joint margins is a most constant finding in those parts which, due to slight subluxation, are out of contact with the antagonist and are, therefore, out of joint play.

Consequently, any corrective osteotomy on the lower extremity (mainly in the trochanteric region) should be performed before skeletal fixation of compensatory (static) spinal curves has occurred,—in other words, before the power of functional adaptation has been fully invested and used up in advanced structural changes. If, in such a stage, the insistence of the patient makes it necessary to perform a corrective osteotomy, the possible benefit from the intervention has to be carefully calculated, and the amount of correction to be given ought to be measured correspondingly. The operation should not be carried out if the functional impairment is not too great and if there is some doubt in the surgeon's mind about the likelihood of improvement. At any rate, the author feels that full correction of the deformity should never be attempted in a case within or beyond the third decade of life, if a flexion-adduction or flexion-abduction contracture of many years' duration has led to a fixed scoliotic and increased lordotic curve of the lumbar spine. The best that can be obtained in such cases is neutral position; often it will even be advisable to leave the limb in a few degrees of adduction. Never should overcorrection be attempted by placing the leg in abduction with the object of compensating for the existing true shortening of the extremity. This procedure, which is as a rule very efficacious in children with limber spines and pelves, is attended by very bad results if performed on adults, whose spines have finally adapted themselves to the faulty statics and display no more regenerative possibilities. Such patients are often not at all benefited by the operation. They may even be much worse after the osteotomy than they were before. The operation, as a rule, has to be

done over again with more approximation to the primary vicious position.

On the other hand, the osteotomy may have been performed too soon at a time when, despite the absence of manifest clinical symptoms, the causative factor of the deformity was still at work. This is true of cases with relatively mild destructive joint lesions in which severe joint contractures may result from intra-articular adhesions or from a more or less localized scarring process of the joint capsule, leading to capsular shrinkage and some muscle spasm. Of especial interest are those cases of destructive (infectious) arthritis in childhood in which, without a more marked degree of destruction, obliteration of the joint space takes place by fibrous adhesions. These cases often show great tendency to joint contractures. The hip joint and the knee seem to be the most frequently involved; the hip joint is apparently affected more often than the knee. The inflammatory process usually subsides under conservative treatment. The concomitant joint contracture, however, represents quite a serious complication in regard to the after-treatment.

As a rule, if there is not too much posterior subluxation of the tibia, a knee-joint contracture can easily be overcome with the aid of traction apparatus or a turnbuckle-cast, and good position can be maintained by a well-fitting long leg brace until the tendency to contracture subsides. Such is not the case with the hip joint. A hip-joint contracture, which is due to fibrous ankylosis following a destructive arthritis, is usually easily corrected by traction. It is, however, very difficult to maintain the corrected position. Single hip spicas or hip braces are of very little help in preventing the quick recurrence of the deformity. The leg draws up, usually to flexion-adduction contracture, and the pelvis accompanies the deformity with a compensatory tilt within the spacious body part of the orthopaedic appliance.

The tendency to contracture following inflammatory joint lesions extends frequently over a period of several years. Clinically, the joint process may appear as healed, but there is still activity with scar formation and muscle imbalance from a pathological view-point. Lorenz, many years ago, in appreciation of this tendency in tuberculous hip disease, suggested the treatment with plaster-of-Paris casts and weight-bearing. He neglected the developing hip deformity entirely and aimed at a solid ankylosis which he hoped would occur under the stimulus of weight-bearing. Once the hip was solid, many years after the onset of the disease, he performed the corrective subtrochanteric osteotomy.

Apart from the questionable occurrence of solid ankylosis in tuberculous hip disease, Lorenz's argumentation seems to be correct. The indication for the osteotomy depends upon the fixation of the contracted position or, in other words, upon the soundness of the destroyed joint. The osteotomy would be futile and the deformity would inevitably recur, if there should still be a tendency to joint contracture. As pointed out, this tendency may be present without any clinical symptoms suggestive

of activity of the disease process. The destruction of the joint alone with the fibrous ankylosis is sufficient reason for the contracture.

Hibbs, approaching the question of tuberculous hip disease from the point of view of uncertainty of permanent cure by the so called conservative treatment, advocated the fusion operation as the treatment of choice and found many followers. It is interesting, however, to find that adduction or flexion contracture does develop in a large number of cases following Hibbs's fusion operation, which otherwise was successful. This bears out the fact that even a strong bone graft placed over the upper side of the hip joint may yield to the persisting pull of muscle spasm and shrinking scar tissue.

It is quite evident that recurrence of the deformity is made easier if the correction of position has been obtained only by the less difficult trochanteric osteotomy and if the joint does not reveal firm bony ankylosis. A relatively short period of time—three to six months—is usually sufficient to show the recurrence of the deformity. In addition to tuberculous lesions, the author has seen a great number of cases of nonspecific hip disease—suppurative synovitis, simple infectious arthritis following open reduction of congenital or traumatic dislocation, etc.—in which an osteotomy had been performed at an apparently quiescent stage of the process with entire immediate success, but the deformity had recurred after a short time.

The following illustrative case was observed in the Orthopaedic Department of the State University of Iowa.

A girl, six years of age, was admitted to the Hospital in July 1931 with bilateral congenital dislocation of the hip joint. She was put in a Hoke-traction cast for five weeks and an unsuccessful attempt at closed reduction was made. Therefore, reduction of the hip by an open operation was tried. This attempt failed also and the secondary acetabulum was reamed out and a bony shelf was built over the head. There was considerable stiffness of the hip following operation. Gradually the right hip went more and more into adduction despite daily physical-therapy treatment and manipulations.

About two years after the shelving operation, a corrective subtrochanteric osteotomy was done. The distal fragment was placed in about 15 degrees of abduction and there occurred good bony union. Nine months after the osteotomy, the hip joint was again held firmly in a position of flexion, 20 degrees of adduction, and 10 degrees of internal rotation. There was no free motion. The roentgenogram showed irregular eroded joint surfaces suggestive of arthritic erosion. The child walked with a marked tilt of the pelvis with extreme lordosis and left convex scoliosis of the lumbar spine. A subcutaneous adductor tenotomy was done to improve the position. The leg could fairly easily be brought out into the straight position. A cast for immobilization was applied for eight weeks.

Half a year later, an extreme adduction contracture had recurred. The hip joint seemed to be stiff on clinical examination, but did not show bony ankylosis in the roentgenogram. Another corrective subtrochanteric osteotomy was performed. After a few months, the same deformity had recurred; the right side of the pelvis was over an inch higher than the left to compensate for the very marked adduction contracture. The roentgenogram showed at the site of the previous osteotomies a pronounced angulation between the upper part of the femur and the diaphysis.

This case, illustrative of the tendency to joint contracture following postoperative (traumatic) arthritis of the hip joint, resisted all attempts at correction by physical therapy, by adductor tenotomy, and by two subtrochanteric osteotomies. Similar cases are by no means rare. They show clearly that the simple subtrochanteric osteotomy, even if the distal fragment is brought into accentuated abduction, is unable to control the tendency to contracture. Such cases certainly require another form of treatment.

One may feel that the osteotomy should be postponed until the joint becomes sound, which means solidly ankylosed. However, it is rather doubtful whether a case will ever go on to spontaneous bony ankylosis, and it does not seem advisable to let the contracture reach its maximum degree. The case just described shows that the tendency to adduction contracture may be present over a number of years, a condition which involves the great danger of spinal deformity. Orthopaedic appliances do not solve the problem for this reason. There would be need of immobilization of both lower extremities to prevent the tilting of the pelvis. In view of the quiescent joint lesion, however, such a rigorous procedure is not warranted.

It seems that the intra-articular arthrodesis is the only logical way out of the difficulties presented by these cases of clinically stiff and painless hips, but without roentgenographic evidence of bony ankylosis. The arthrodesis is indicated for several reasons. When performed by an experienced surgeon, it is a relatively simple procedure which can safely be carried out in thirty minutes. It does not disturb to any marked degree the anatomical condition of the bony joint constituents. It is limited to the complete removal of the joint cartilage and the scar tissue interposed between the joint ends and to the opening of the superficial marrow spaces of the head and the acetabular cavity. It does not affect the epiphyseal plate at the upper end of the femur. This is the main reason why the simple intra-articular arthrodesis is preferable to the extra-articular form with the bone graft, which necessarily blocks the epiphyseal line. It is quite certain that a solid ankylosis, procured by intra-articular fusion, is better able to withstand the pull of the adductor muscles and the shrinking scar tissue. Small reenforcing bone chips, removed from the wing of the ilium, can be placed around the rim of the acetabulum, but not across the epiphyseal plate.

Inasmuch as the majority of these patients are children, quite often with very little bone destruction, the bony ankylosis obtained by intra-articular arthrodesis prepares the way for a possible arthroplasty at a later date. Every subtrochanteric osteotomy, from the standpoint of the osteotomized bone, has to be considered as a poorly healed fracture, in which the kinking of the fragments shortens the bone to a variable degree, corresponding to the amount of deformity to be corrected. It, therefore, represents a disadvantage if an arthroplasty is contemplated later.

ACUTE TRANSVERSE BONE ATROPHY *

BY WALTER G. STERN, M.D., F.A.C.S., CLEVELAND, OHIO

The importance of recognizing acute bone atrophy or, rather, calcium resorption as the underlying cause of many cases of pain and disability of the extremities (Sudeck's atrophy, spotted atrophy, etc.) is being so universally acknowledged that the presentation of another and hitherto undescribed variation of this same phenomenon is not out of order.

After plaster fixation of the limb for fracture of the lower extremity, in young adults between the ages of twenty and thirty-five, the author has often noted a wide and distinct transverse band of radiolucency appearing on the roentgenograms, usually in a position diaphyseal to the union of the metaphysis with the epiphysis,—in the position of the so called "*Gerüstmarkzone*" of infantile scurvy—which, if unappreciated, can lead to a false diagnosis of disease or fracture in this area. This phenomenon has also been observed in three cases of non-suppurative infection in a neighboring joint and in two cases of tumor formation in the limb. The appearance of this transverse zone of bone resorption can best be portrayed in the words of Baetjer in his description of the "*Gerüstmarkzone*" or, as he calls it, "*Trümmer Zone*" in scurvy: "This band produces an appearance on the plate as if a surgeon had roughly operated and removed a narrow cross-section of the bone." The localization of this transverse atrophy is usually peripheral to the site of the injury, but, as King has shown in his latest monograph on bone atrophy, transverse atrophy, like the spotted type of acute or Sudeck's atrophy, can also appear in the bones proximal to the lesion.

The writer has seen fifteen of these cases—at least half as many as he has seen of Sudeck's spotted atrophy—and could further quote many more cases which have been observed by various correspondents who have kindly offered him the histories and roentgenograms of their cases for publication, but which he feels will carry more weight when published by them individually. Unlike the cases of Sudeck's atrophy, which usually occur in the smaller bones, the author's cases, with but one exception, have been confined to the long bones of the lower extremity,—usually to the lower end of the tibia. There have also been three cases of transverse atrophy at the upper end of the tibia and the lower end of the femur,—one through the neck of the femur (horizontal) and another vertically through the neck of the scapula.

The following cases are typical of this form of atrophy.

CASE 1. A male, aged twenty-three, on "poor relief" for the past three years, whose diet had consisted chiefly of cheap carbohydrates with sufficient proteins and fats, but with very little fresh fruit and few vegetables, tripped on the floor of his home in Novem-

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 14, 1936.

ber 1934 and received a transverse fracture of the fibula, about one inch from the lower end, and a vertical crack fracture of the internal condyle of the tibia. With the exception of these changes, the roentgenographic examination (Figs. 1 and 2) was negative. The usual biochemical blood and urine tests, including phosphorus-calcium ratio, were negative. The patient had more than the ordinary number of carious teeth, but ascribed this to the fact that the family were on "poor relief" and consequently he had not had dental care for several years.

The patient was immediately placed upon a diet rich in vitamin C, and a circular plaster cast with a walking iron was applied. He was then encouraged to walk about, first on his crutches and then without them. He seemed unwilling to do this because of pain in the ankle and swelling of the toes.

When the cast was removed, five weeks after the injury, a wide, transverse, sharply defined, radiolucent band of bone absorption was noted in the roentgenograms just proximal to the usual occurrence of Guérin's line (Fig. 3). There was no trophoedema of the leg, foot, or ankle; the color of the parts was normal. There were no pressure marks from the cast, which had been fairly heavily padded. The usual tests for sufficiency of the arterial circulation gave normal results.

Six weeks later a second check-up roentgenogram showed a decrease in the intensity of the rarefaction. A final roentgenographic examination, made three weeks later, still showed the band, but much less distinctly (Figs. 4 and 5).

CASE 2. A male, aged twenty-two, had been ill in bed for four months with pain in the left thigh and knee, and was said to have had fever and night sweats for one month. Early roentgenograms were reported to have shown a "loosening of the lower epiphysis" of the femur. The swelling had slowly subsided.

At the time of the author's examination, six months after the onset of the process, the left knee was symmetrically swollen and held in a position of 45 degrees of flexion. Further flexion of 45 degrees was free and unimpeded. Complete flexion and extension

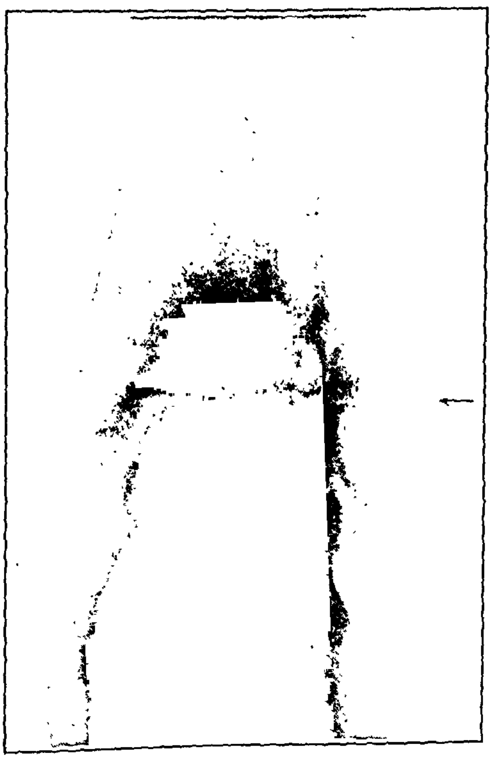

FIG. 1

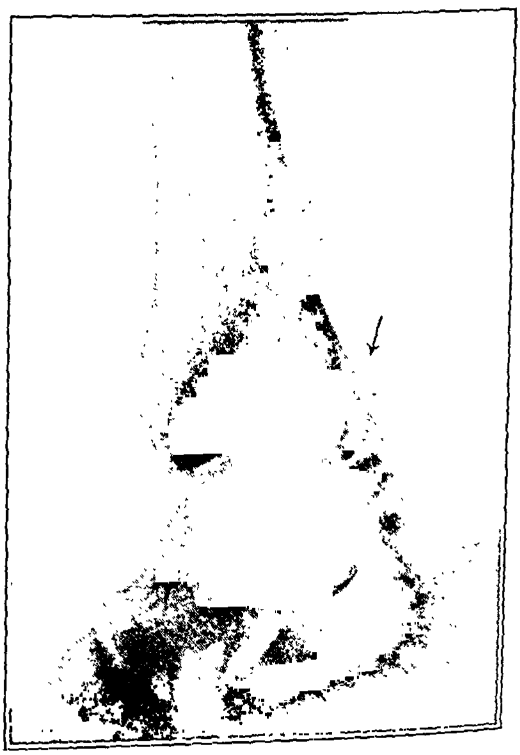

FIG. 2

Fig. 1: Case 1. Arrow points to fracture of the fibula. This is not a persistent epiphyseal line as shown by the healing in Fig. 4.
Fig. 2: Case 1. Arrow points to fracture of the tibia.

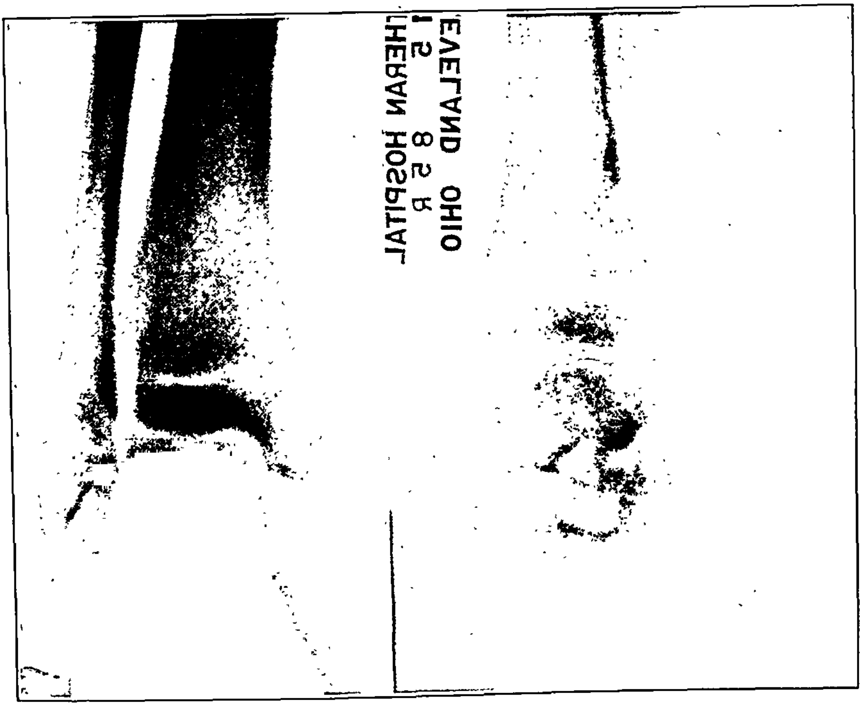

FIG. 3

Case 1. Lower part of the tibia five weeks after injury.

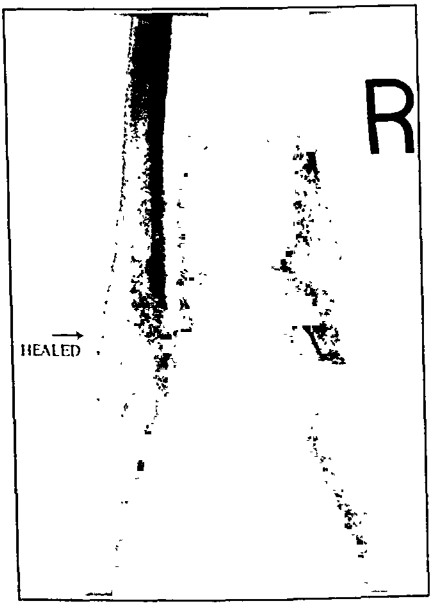

FIG. 4

Case 1. Transverse atrophy of the lower end of the tibia nine weeks after Fig. 3. Note healing in the fibula.

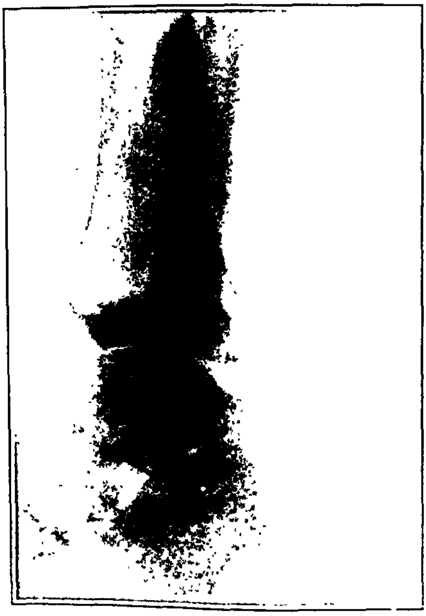

FIG. 5

Case 1. Transverse atrophy of the lower end of the tibia nine weeks after Fig. 3.

were impossible and attempts at such motion were quite painful. There was no free fluid in the knee joint, and no especial areas of tenderness about the knee joint. The hip was negative. *Differential tuberculin tests and the usual laboratory biochemical tests* were negative. The phosphorus-calcium content of the blood was normal.

Roentgenographic examination showed a mild generalized atrophy of the tibia and fibula, in addition to which there was a marked transverse band of decalcification just diaphyseal to the epiphyseal line both of the tibia and of the fibula (Fig. 6).

The patient was given an anaesthetic, and the knee was straightened out and fixed in plaster. After a short time, a walking caliper brace was used. The patient was given sun baths, fresh air, and a high-caloric and high-vitamin diet.

Roentgenograms taken six months later showed that the atrophy had practically disappeared. The patient is making steady and uninterrupted progress toward recovery.

A most unusual and bizarre combination of symptoms occurred in the following case.

CASE 3. A young woman, aged twenty-three, slipped and fell early one morning while at work, striking her buttocks. She arose, went about her duties as a clerk, and did not feel the need of medical aid on account of her injury.

Two weeks later she suffered from a severe quinsy sore throat and, before she had

FIG. 6

Case 2. Transverse atrophy in the tibia and femur after acute non-suppurating arthritis.

completely recovered, she was seized with a sudden, sharp, excruciating pain in the hip of the same side which she claimed to have injured. She was put to bed by her attending physician. After three weeks at home, she was transferred to a hospital. A roentgenogram of the hip was taken and was found to be negative in all respects. Buck's extension was then applied. A diagnosis of gonorrhoeal arthritis was made, although the patient denied ever having had intercourse, and cervical and urethral smears, as well as the gonorrhoeal complement-fixation tests, were negative.*

Six months later a second roentgenogram was taken and was also pronounced negative. However, the author believes one can see a narrowing of the joint space, destruction of the cartilage of the upper pole of the hip joint, and a faint transverse line of radiolucency running through the lower part of the neck of the femur.

After five months' rest in bed and fixation, the hip was stiff and painless. A third roentgenogram revealed further destruction of the cartilage of the hip and a wide, well-defined transverse band of radiolucency extending through the lower part of the neck of the femur, from the head of the femur through the trochanter (Fig. 7).

A diagnosis of ununited fracture of the femur was then made, and the case was certified for industrial accident insurance, which the insurance carrier refused. Finally, a compromise was effected and the patient was sent for observation to one of the major surgical clinics, where the diagnosis of ununited fracture was concurred in. A bone-graft operation was advised and refused, and in the spring of 1934 the patient returned to her home.

She gained rapidly in health and well-being, so that by fall of the same year the insurer believed her capable of going back to her former occupation of store clerk. She refused, claiming disability because she could not bend her hip to sit down in comfort. She again visited the surgical clinic for operative advice and an arthroplasty was decided upon. This, however, was refused by the insurer and the employer. The patient was then sent to the author for examination, estimation of disability, and advice as to treatment.

FIG. 7

Case 3. Transverse atrophy of the neck of the femur.

The entire medical history and hospital records accompanied her and, in spite of the insistence now that her disability followed at once upon her injury, the medical sequence of affairs was absolutely clear and was as given here in brief. Excellent roentgenograms in proper sequence were found in the legal file, all properly labeled and identified.

Examination showed a solidly ankylosed hip—painless and symptomless—and the

* The author believes the acute phase of this case is somewhat like that form of acute arthritis which he described at the Minneapolis meeting of the American Medical Association as "acute, painful, ankylosing arthritis" and which others (he believes mistakenly) held to be gonorrhoeal. Repeated vaginal examinations and smears revealed an intact hymen and no purulent discharges. The urethral and cervical smears were negative, as were also the precipitation and gonorrhoeal complement-fixation tests.

patient walked so well in her high heels that with her clothes on it was hard to tell from her gait that she even had an ankylosed hip. The final roentgenograms showed a solidly ankylosed hip. The line of transverse atrophy had entirely disappeared and there was no angular deformity, overriding, or shortening such as one would expect even with a spontaneous fracture.

This is distinctly not one of those cases of spontaneous fracture in this region which have been reported, especially by Milkman. These spontaneous fractures, of course, never heal and the post-mortem findings show an increasing vascularity in the zones of transverse transparency, which, according to Milkman, suggest some trophic disturbance (Looser Zone).

While the ultimate cause of bone atrophy in general is still shrouded in considerable mystery or only hazily surmised, we are now positive of one thing, and that is that bone atrophy is not caused by circulatory deficiency. Bone is considered to be one of the most unstable of all tissues, since lime is being constantly absorbed and redeposited in equal amounts. The thought that deficient circulation led to deficient calcium deposit and bone reproduction was, of course, enticing, but it has been shown by a host of experimenters and writers—among whom are Key, Phemister, Murray, and Harris—that where the blood supply is cut off, as for instance in the case of a fracture of the head of the femur, calcium resorption or bone atrophy does not take place.

The experiments of Leriche and others show: that a normal circulation results in normal bone calcification; that an excessive supply of blood to the part, plus an unknown factor, causes bone resorption; and that a diminution of blood supply results in sclerosis. Even here some of the moderns, as for instance Axhausen, Destat, Presier, Kienböck, and others, tend to "backslide" a little when they attempt to explain the sharp localization of post-traumatic atrophy in some of the carpal bones. As King has so succinctly stated, "It is probable, however, that both the bone resorption and the vascular dilatation are the result of an alteration in the conditions present in the part, the exact type and degree of alteration and its cause being still uncertain." He also claims that the experimental production of a typical "acute bone atrophy" has not yet been achieved by anyone. Phemister, the author believes, also agrees to this.

Can it be that the unknown factor at work in these cases of bone atrophy is the same as is seen in certain generalized diseases of childhood—rickets and especially scurvy—in which bone atrophy or, rather, calcium resorption plays such an important rôle, and in which, through the lack of certain vital principles of nutrition (called by Burrows "ergusia", now better known as "vitamins"), orderly bone growth and metabolism are interfered with and calcium is lost from certain specific areas? In one of his papers Hess remarks: "Occasionally oedema rather than hemorrhage has been found in the scurvy of adults." As before stated, could one but reproduce experimentally in adult animals the conditions here under discussion, the problem might be easily solved. The improvement

in several of our cases after having been placed on a high-vitamin diet must be looked upon merely as a coincidence, however enticing it may be to speculate upon cause and effect.

SUMMARY

Attention is called to the occurrence of a form of acute bone atrophy seen in young adults, usually after fixation of a limb for fracture. This phenomenon has also been seen by the author in four cases after disuse because of non-purulent infection in neighboring joints, and in two cases of tumor formation in the limb. This type of atrophy takes the form of a broad translucent band of bone resorption on the diaphyseal side of the epiphyseal line, parallel to the axis of the neighboring joint. This band occupies the same position as does a similar band of radiolucency in scurvy, which is sometimes called "*Trümmer Zone*", "*Trümmerfeld Zone*" (Baetjer-Windberger-King), or "*Gerüstmarkzone*" (Harris-Lehndorf). This peculiar form of atrophy should not be mistaken for fracture or acute disease.

An unusually complete and extensive bibliography on this subject is contained in the latest publication by Dr. E. S. J. King, of Melbourne, Australia. Other authors who are not included in Dr. King's bibliography, but who have contributed to our knowledge of this type of atrophy, are: Baetjer and Waters, Burrows and Johnston, Fraenkel and Gorey, Ghormley, Goldblatt, Gurd, Harris, Jones and Roberts, Karsner, Milkman, Murray, Phemister, and Williams.

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SCOLIOSIS: ITS PROGNOSIS

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For the past 100 years there has been much confusion regarding the natural course of scoliosis. Many ideas have been expressed which have been based on impressions rather than on actual examinations of the patient or his deformity.

In order to arrive at an opinion based on accurate measurement, all of the untreated cases of scoliosis with standard roentgenographic examinations and growth measurements at the New York Orthopaedic Dispensary and Hospital have been studied. There were 296 cases (57 males, 239 females). Measurements of height, while sitting and standing, and roentgenograms in the erect and recumbent postures were included in the examination of every patient. Curvature was measured in the roentgenogram as described in a previous paper[1].

No case was omitted because of severity of curvature. If the patient was not suitable for surgical treatment, but did return for subsequent examinations, he was included in this study. In the erect posture, 52 per cent. of the curvatures measured from 20 to 40 degrees; 20 per cent., from 40 to 60 degrees; 9 per cent., from 60 to 80 degrees; and 5 per cent., more than 80 degrees.

Right-dorsal left-lumbar curves were present in 78 per cent. of the cases, and left-dorsal right-lumbar curves in 22 per cent.

The fifty-one paralytic cases (18 males, 33 females) comprised 31.5 per cent. of the males and 13.8 per cent. of the females.

The age of cessation of rapid vertebral growth of adolescents was determined from forty-seven cases observed in and after the growth period. In this group, growth in sitting height ceased on the average at the age of sixteen and one-third years in males and fourteen and one-fourth years in females. The extremes of age were: in males, fourteen years in two cases, seventeen years in four cases; in females, twelve and one-half years in one case, thirteen years in ten cases, and sixteen years in three cases. In each case curvature increased during the growth period and not thereafter.

Twenty-nine other patients seen during the adolescent growth period have not yet ceased growing, but have not exceeded the average or the maximum of the above group.

One hundred and thirty-four patients were seen after cessation of vertebral growth, but before the maximum age for arrest of growth. In these growth was known to have ceased in the eighteen males at the age of fifteen and one-half years on the average, the extremes being fourteen

and seventeen years, and in the 116 females at the age of fourteen and one-third years on the average, the extremes being twelve and sixteen years. In no case was there an increase in the curvature.

The findings in these cases indicate that cessation of vertebral growth and arrest of progress of curvature may be expected at or before the age of seventeen in males and sixteen in females.

Two hundred and fifty-five cases were observed after growth in height had ceased. Twenty-two of these cases were observed less than one year. These cases conform to the findings of the group as a whole, but are hereafter disregarded because of the short period of observation. The forty-seven cases followed through the adolescent growth period were observed thereafter for an average of three and two-tenths years for the males and two and eight-tenths years for the females, the longest period being eight years for each sex. Increase in sitting height per year during this period averaged eight hundredths of an inch in males and one-tenth of an inch in females. This is within the limit of error of measurement. At the same time, standing height increased per year three-tenths of an inch in males and two-tenths of an inch in females. In no case was there an increase in the curvature.

One hundred and eighty-six cases, first seen when growth in height had ceased, were observed from one to eleven years, the average being two and three-fourths years. Twenty-one of these were observed more than five years. In no case was there an increase in the curvature during the period of observation.

While in none of the 255 cases was there an increase in curvature after cessation of vertebral growth, increase was regularly observed during the growth period. This relation is shown in the following: The forty-seven cases examined during the period of rapid growth and thereafter were observed on the average two and one-tenth years before growth had ceased, the longest periods being five years in four males and eight years in one female. During this growth period, the average yearly increase in curvature was 5.9 degrees in males and 8.2 degrees in females. At the same time the average yearly increase in sitting height was forty-four hundredths of an inch in males and nine-tenths of an inch in females; in standing height, ninety-four hundredths of an inch in males and one and seven-tenths inches in females.

The twenty-nine patients who did not complete their growth during the period of observation were younger. At the start of observation the males averaged eleven and one-third years and the females, twelve years. The average duration of observation was three years in the eleven males and two and six-tenths years in the eighteen females. The average yearly increase in curvature was 5 degrees in males and 8 degrees in females. The greatest yearly increases were 10 degrees in a male in the age group from twelve to sixteen years, 19 degrees in a female with collapse of the lung, in the age group from thirteen to fifteen years, and 13 degrees in a female in the age group from thirteen to fifteen years. Increase in curva-

ture was slight at the ages from five to ten years. The usual yearly increase in sitting height was one-tenth to four-tenths of an inch at ages from four to twelve in males and from three to eight in females; one to one and one-half inches at ages from twelve to fifteen in males and from ten to fourteen in females.

The observations that have been cited indicate that rapidity of increase of curvature corresponds with rapidity of vertebral growth, and that increase of curvature ceases when growth in sitting height ceases,—that is, not later than seventeen years in males and sixteen years in females. The etiology of the curve did not affect its relation to growth. In cases of paralysis and of hemivertebrae, and in those due to unknown causes, the curvature increased with growth and remained stationary when growth ceased.

Of the 296 cases in this study, twelve were regarded as exceptional and are not included in any of the groups described. In six of these, there was no increase in the curvature within the age period from ten to sixteen, although the average yearly increase in sitting height was nine-tenths of an inch. In another case, there was no increase in curvature from the age of seven to the age of thirteen, although sitting height increased six and nine-tenths inches in this time. These were all mild curves.

In two cases of marked kyphosis there was an increase in the angle of curvature at or after cessation of growth. This was believed to be due to enlargement of the kyphos rather than to increase of the lateral curvature. In another case the curvature increased after the age of thirteen, but the interval between examinations was too long to determine when the increase occurred.

One case was exceptional in that there was some decrease in the curvature between the ages of ten and sixteen.

Another patient wore corrective plaster jackets until he was eighteen and one-half years of age. Thereafter until he was twenty-one and one-half years of age his curve increased from 67 to 75 degrees. This is not an untreated case, but is included to illustrate that when the spine is held up by plaster it may be expected to sag when the plaster is removed, regardless of age.

It has frequently been stated that flexibility of the spine causes scoliosis to become worse. The fact that exercises maintaining flexibility are usually begun at the age when the curve is increasing because of rapid growth may be the basis for this belief. Many patients in this series had postural exercises, including some flexibility exercises, but in no case was there an increase in curvature after cessation of vertebral growth. One girl with a curvature of 70 degrees was a gymnasium teacher for eleven years, during which time there was no increase in deformity. Another girl, aged fourteen and one-half, with a curvature of 75 degrees, was an acrobatic dancer. She had a very flexible spine. She has continued vigorously her acrobatic dancing with no increase of deformity. She was last seen at the age of sixteen and one-half.

CONCLUSIONS

Growth in vertebral height ceases in girls at or before the age of sixteen, the average age being fourteen; in boys, at or before the age of seventeen, the average age being sixteen.

Increase in curvature in scoliosis ceases when vertebral growth stops.

The spine grows slowly in boys from the ages of four to eleven, and in girls from the ages of three to nine; but growth is rapid in adolescence. Rapidity of increase of curvature corresponds to rapidity of growth.

The relation of increase of curvature to growth is not materially influenced by the etiology of the curve.

The effectiveness of various methods of treating scoliosis for prevention of progress of curvature must be judged in adolescent patients who have not ceased growing. After growth has ceased, treatment for this purpose is superfluous.

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INFLAMMATORY LOCALIZED LESIONS OF THE JUXTA-EPIPHYSEAL ZONE OF THE NECK OF THE FEMUR

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TRANSLATED FROM THE ITALIAN BY ERNST FREUND, M.D., VENICE, FLORIDA

Localized lesions of the neck of the femur, due to tuberculosis or to common pyogenic organisms, have long been recognized and studied by anatomists, while they have still remained hidden from the clinicians in the huge group of inflammatory hip diseases. To roentgenology belongs the credit for having shown the way in the research and definition of finer clinical symptoms, so that gradually a typical clinical picture with a true nosological entity could be made out. Localized lesions of the neck of the femur were described by Sourdat (1909) in a purely roentgenographic study and by Waldenström (1908–1910) in several articles in which he published the results of very careful anatomical, roentgenographic, and clinical investigations. Later on, with the perfection of technical means, the progress of physical symptomatology, and the development of more accurate roentgenographic and clinical diagnoses, the recognition of these lesions became more frequent. At present, however, the interest in juxta-articular lesions has greatly decreased, because their clinical and roentgenographic appearances have become so well known. In the interpretation of clinical facts, it has been necessary to concentrate more on etiology and pathogenesis.

After making arteriographic studies of the normal vascularization of the neck of the femur in different ages, the author has been able to deter-

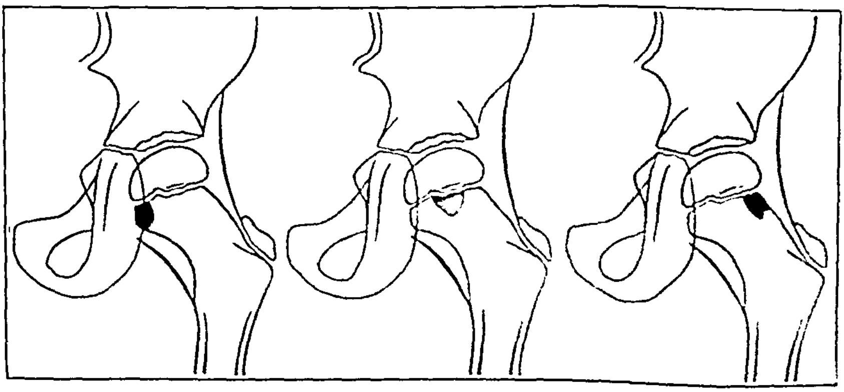

FIG. 1

Showing the three areas in the juxta-epiphyseal zone in which the inflammatory lesions are usually localized.

* Prof. A. Mezzari, Director.

mine why such localized tuberculous lesions are frequently found in children but do not occur in adults. With these findings, it has been possible to differentiate lesions of varying localization which correspond to a definite topographical and anatomical pathology and also to the clinical picture. Thus, four principal types of localized tuberculous lesions of the neck of the femur have been distinguished as follows: (1) foci in the lower cervicodiaphyseal arch; (2) foci with juxta-epiphyseal localizations; (3) foci with bulbometaphyseal localizations; (4) foci with metaphyseal-subtrochanteric localizations.

In this paper, the author wishes to discuss the juxta-epiphyseal localizations, using as a basis the cases seen at the *Ospedale Marino "Elena Duchessa d'Aosta"*. To the lesions due to the tubercle bacillus, other interesting but lesser known pyogenic lesions have been added. Thus it is possible to point out the differential facts in the early symptomatology and in the clinical course, and to draw practical conclusions of great importance. The following cases are presented in the hope that they may contribute to a clearer understanding of the nature of these lesions.

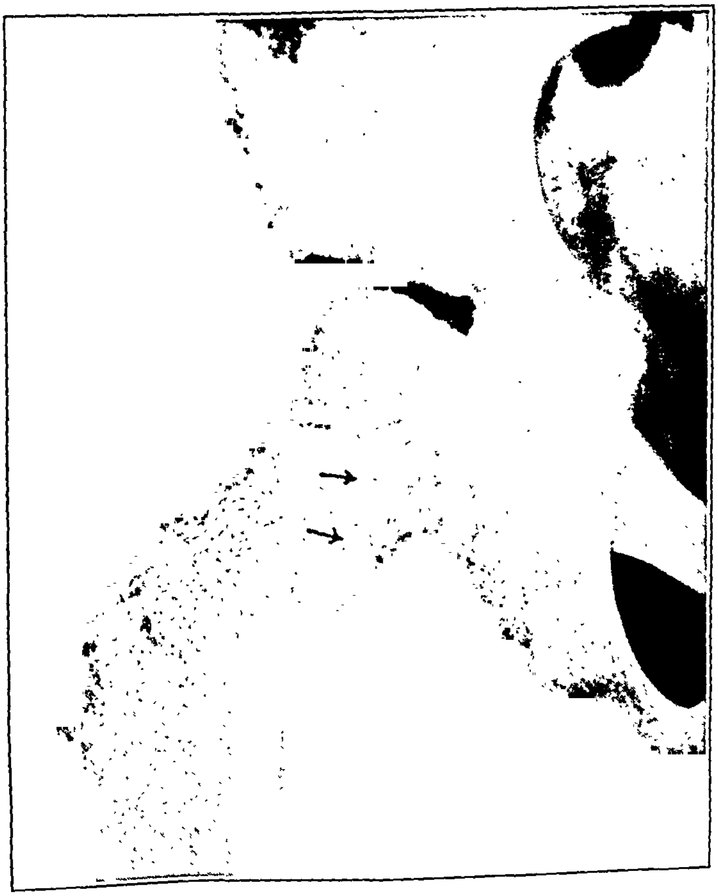

Fig. 2

Case 1. M. A., a boy, nine years of age. Tuberculous focus in the inferomedial portion of the juxta epiphyseal zone.

FOCI IN THE INFERO-MEDIAL PORTION

Case 1. M. A., a boy, nine years of age. During the year previous to admission the hilar lymph nodes had enlarged and moderate pain of intermittent character had appeared in the region of the right hip, accompanied by fatigue and a limp.

At examination the patient's general condition was found to be fair. There was enlargement of the lymph nodes in the right groin. The right lower extremity was externally rotated and there was tenderness on pressure over the head of the femur and the greater trochanter. Motion was present as follows: flexion, 110 degrees; internal rotation, abduction, adduction, and hyperextension, slightly limited.

A roentgenogram (Fig. 2) revealed a focus in

the inferomedial portion of the juxta-epiphyseal zone, partially defined by reactive perifocal sclerosis. Otherwise, the findings were normal.

Diagnosis: Tuberculous focus in the lower portion of the neck of the femur.

Treatment consisted of immobilization. Panarthritis developed fourteen months after the patient's admission to the hospital.

FOCI OF THE INTERMEDIATE TRACT

CASE 2. D. B., a boy, four years of age. Three months before admission a slight limp had developed. The child was easily fatigued, but suffered no pain. During the month prior to admission, there was marked pain in the right hip, associated with a limp, rapid loss of weight, and fever.

The boy appeared pale and emaciated. The right hip joint was swollen and hot. There was extreme tenderness to direct and indirect palpation. Weight-bearing was possible and gait was painless with a limp.

Roentgenographic examination (Fig. 3) showed the acetabulum and joint space to be normal. The head of the femur was markedly osteoporotic. The upper epiphyseal plate was irregular with hazy outlines. A very dark, shadowlike sequestrum was present in the intermediate portion of the juxta-epiphyseal zone, surrounded by a dense zone and moderate perifocal reaction.

Diagnosis: Tuberculous focus of the intermediate portion of the juxta-epiphyseal zone.

Two months later panarthritis developed. Three months after admission an abscess formed in the upper corner of Scarpa's triangle and broke through after two more months.

Treatment consisted first of immobilization in a plaster cast. Fourteen months later, an operation was performed in which the sequestrum was removed and the wound was closed. The patient is still under treatment.

CASE 3. G. G., a boy, three years of age. At the age of six months, tenderness had

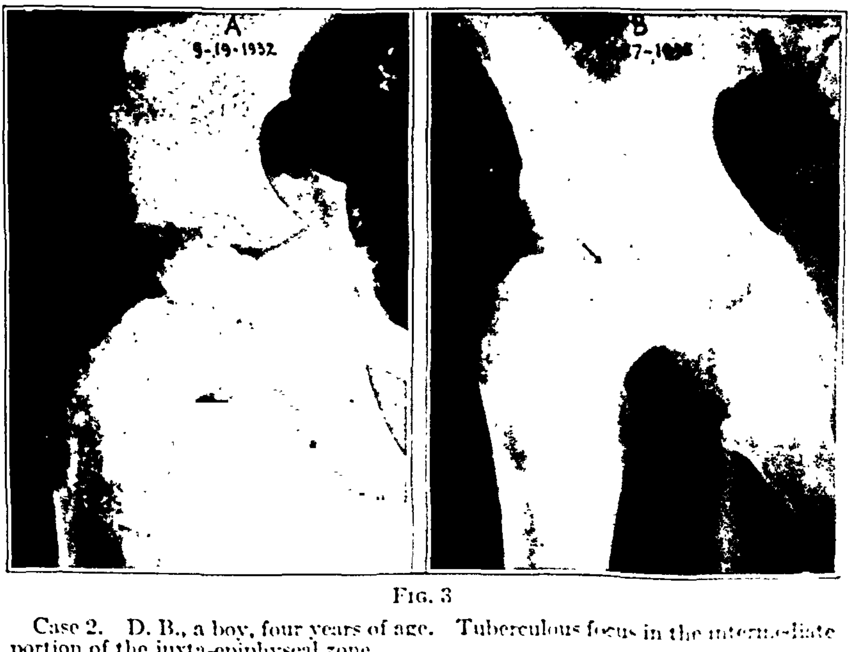

FIG. 3

Case 2. D. B., a boy, four years of age. Tuberculous focus in the intermediate portion of the juxta-epiphyseal zone.
A: September 19, 1932. *B*: March 27, 1935.

FIG. 4

Case 3. G. G., a boy, three years of age. Old suppurative arthritis of the right hip. Osteomyelitic focus in the intermediate portion of the juxta-epiphyseal zone.

been noted over the region of the right hip. The patient had started to limp at the age of fourteen months. Physical examination disclosed a pathological dislocation of the right hip, and this diagnosis was confirmed by roentgenogram.

Treatment consisted of open reduction of the right hip. Eight months after operation, following a boil on the back, stiffness appeared in the left hip. The hip was cool, dry, and painless, and was held in moderate abduction. Motion was present as follows: flexion-extension, 30 degrees; abduction and adduction, 10 degrees; rotation, 5 degrees.

FIG. 5

Case 4. DeC. F., a boy, five years of age. Tuberculous focus in the superolateral portion of the juxta-epiphyseal zone.

X-rays (Fig. 4) showed the upper end of the right femur to be well placed at the outer edge of the acetabulum. A dense wedge-shaped shadow suggesting a sequestrum, surrounded by a zone of osteoporosis, was present in the metaphysis of the left femur. There was moderate perifocal reaction, and expansion of the joint capsule was noted. There were no signs of porosis.

Diagnosis: Osteomyelitic focus in the intermediate portion of the juxta-epiphyseal zone without joint invasion.

FOCI IN THE SUPEROLATERAL PORTION

Case 4. DeC. F., a boy, five years of age. One and one-half months before admission moderate pain had appeared in the right hip, associated with a persistent limp and a poor appetite. No fever was present and there were no general symptoms.

At examination, the general condition was fair. The right lower extremity was kept in external rotation and 20 degrees of flexion. The hip region was cool, dry, and not tender. Motion in the hip was as follows: flexion-extension limited to 10 degrees; abduction, to 30 degrees; internal rotation, nil; other movements normal. There was no shortening. Atrophy of the thigh, amounting to one centimeter, was noted.

Roentgenographic examination (Fig. 5) revealed in the superolateral portion of the juxta-epiphyseal region a sharply outlined focus with small spots of increased density in the inner portion. A double zone of perifocal reaction could be seen,— one area was located immediately around the focus and the other was situated farther away in the metaphysis. The capsular shadow was slightly expanded. Signs of an old mediastinal pleurisy were evident on the right.

Diagnosis: Tuberculous focus of the superolateral portion of the juxta-epiphyseal zone.

Treatment consisted of immobilization. Three months after admission to the hospital, the lesion was still circumscribed and had not invaded the joint. There was, however, some capsular thickening. Moderate pain was elicited on pressure over the whole area. Motion was as follows: flexion, 85 degrees with pain in the last degrees; adduction, 5 degrees; abduction, 15 degrees; internal rotation, one-third of normal; external rotation, complete. No abscesses were present. There was a distinct limp and the leg was held in a position of abduction and outward rotation.

Fig. 6

Case 5. F. G., a boy, sixteen years of age. Tuberculous focus in the superolateral portion of the juxta-epiphyseal zone.

Case 5. F. G., a boy, sixteen years of age. One year before admission he had suffered an injury to the region of the right hip. One day later fever had appeared, accompanied by local pain and redness. The patient had been given rest in bed for three months. He had then been permitted to get up although the limp and pain in the hip persisted. After three months two sinuses had appeared below the greater trochanter, one of which was still discharging on admission.

The right lower extremity was in normal position and there was no shortening. There was full range of motion in the extremity.

Roentgenographic examination (Fig. 6) showed a round focus of circumscribed osteoporosis in the superolateral portion in the juxta-epiphyseal zone. There was also evident a channel-like band of bone resorption, which started in the most inferior point of the focus of rarefaction and extended toward the greater trochanter. Very little perifocal reaction was noted. The joint space was slightly decreased.

Diagnosis: Tuberculous focus in the superolateral portion of the juxta-epiphyseal zone.

Treatment consisted of immobilization. During an observation period of six months several soft-tissue abscesses and other bony lesions of tuberculous nature developed. The motion in the hip joint became considerably restricted. The muscles atrophied and a slight limp appeared.

CASE 6. M. A., a girl, two years of age. Six weeks before admission a high fever had developed and there was pain in the right hip region.

Physical examination showed the child to be in fair general condition. There was lymphadenopathy in the groin. The hip was kept in 15 degrees of flexion, 5 degrees of external rotation, and 10 degrees of abduction. It was slightly swollen and very tender on pressure. Motion was present as follows: 90 degrees of flexion, 10 degrees of abduction, 10 degrees of adduction, 10 degrees of external rotation, no internal rotation. There was no shortening, but atrophy of the hip muscles was evident. The patient limped and maintained the hip in a slightly flexed and adducted position.

Roentgenographic examination showed osteoporosis and slight narrowing of the hip-joint space. The capsular shadow was expanded upward. A radiotranslucent zone with an irregular outline was present in the superolateral portion of the neck. This zone extended into the interior portion in the form of a slightly darker area, and occupied three-fourths of the neck of the femur. A shadowlike sequestrum, with hazy outline and complete absence of reactive sclerosis, was seen in the inner portion of the neck. There was elevation of periosteum along the diaphysis (Fig. 7).

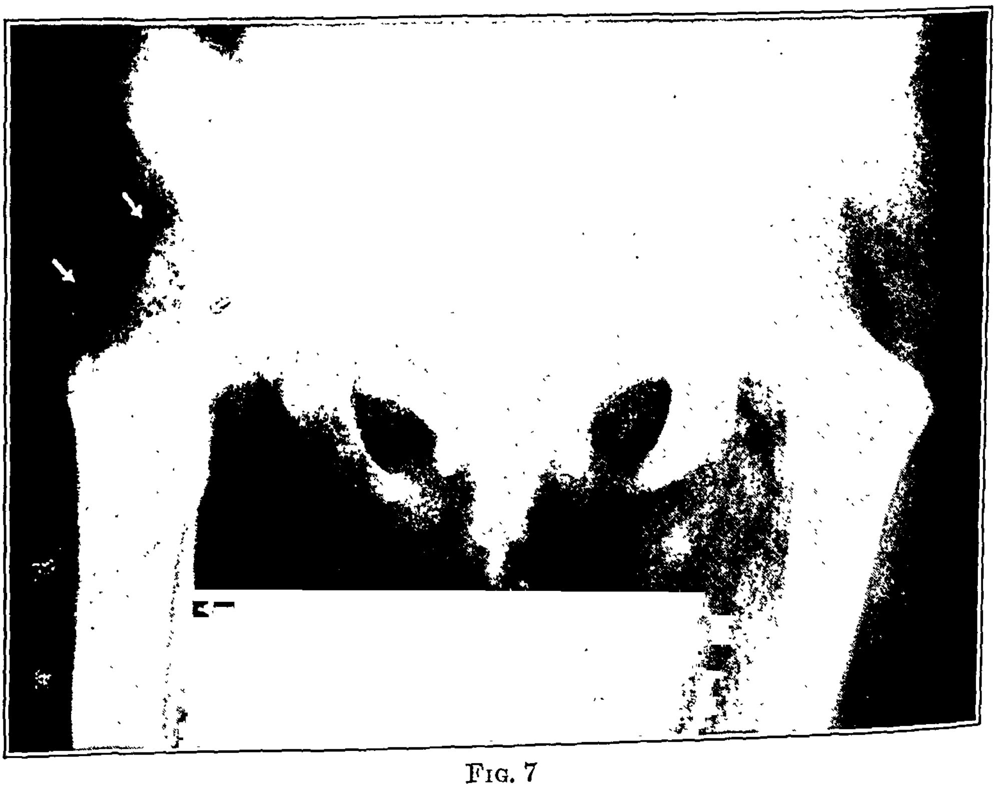

FIG. 7

Case 6. M.A., a girl two years of age.

Diagnosis: Tuberculous focus in the superolateral portion of the juxta-epiphyseal zone.

Treatment consisted of immobilization. Panarthritis developed six months after admission.

CASE 7. N. B., a boy, four years of age. Five months before admission a high fever had developed, associated with extreme pain in the left hip, which became fixed in flexion. The temperature remained elevated for about one month. Treatment had consisted of traction and a plaster cast.

On admission, the patient's general condition was poor. Motion was present as follows: flexion, 30 degrees; abduction, 15 degrees; and slight external rotation. Swelling of the thigh was noted and there was slight pain on pressure over the head of the femur. Some passive motion was possible. There was no fever.

Roentgenographic examination (Fig. 8) revealed that the upper epiphyseal plate, especially on the medial side, was not sharply outlined. There was a wedge-shaped lesion, like an infarct, in the upper lateral portion of the juxta-epiphyseal zone, surrounded by sclerosed bony tissue which had lost its normal trabecular structure. Periosteal and endosteal reactions extended downward along the diaphysis, especially on the inner side.

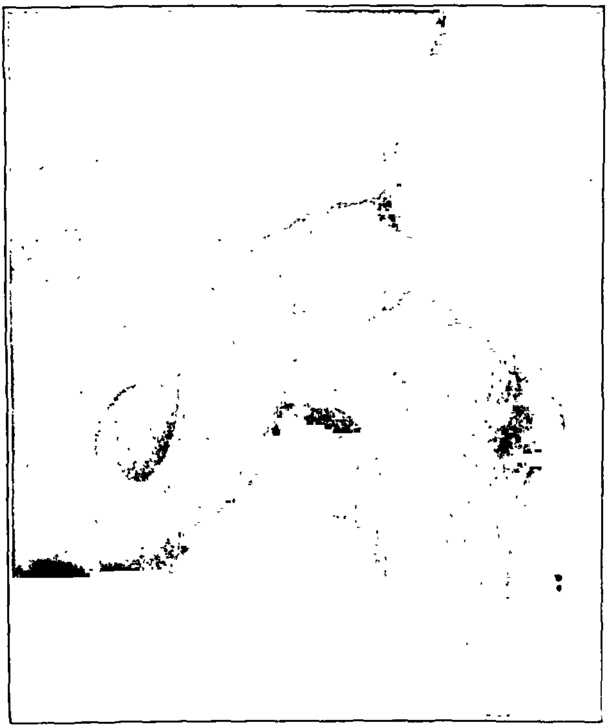

FIG. 8

Case 7. N. B., a boy, four years of age. Osteomyelitic focus in the superolateral portion of the neck of the femur.

Diagnosis: Osteomyelitic focus of the superolateral portion of the juxta-epiphyseal zone.

Treatment consisted of incision and drainage of the hip region and curettage of the bony cavity. Thick pus with staphylococcus citreus was evacuated.

The patient was discharged one month after operation in excellent general condition. The hip had healed and was only slightly limited in abduction and flexion.

LOCALIZATION

The roentgenograms of the cases presented show clearly that the inflammatory processes in the juxta-epiphyseal zone of the femoral neck may have three localizations,—the inferomedial, the intermediate, and the superolateral positions. It seems that the interposed areas are immune and become involved only by expansion of the lesions in the neighborhood.

These inflammatory changes in the neck of the femur develop mostly

at a certain age, from two to eight years. They are rare from eight to twenty years of age, and, if present beyond this age, they are almost always of different etiology and origin.

If it is admitted that the usual mode of infection of bony lesions is embolic through the arterial system, the explanation of these facts can be obtained only by accurate knowledge of the anatomy of the vessels in these regions. The juxta-epiphyseal region of the femoral neck obtains its blood supply in childhood, the period of the greatest frequency of the disease, as follows:

1. By a terminal artery which passes superficially the spongy bone of the inferomedial portion of the neck and ends in the superior region of the epiphysis;
2. By a terminal artery which reaches the epiphysis through the intermediate portion of the neck;
3. By a terminal artery which ramifies in the superolateral portion of the neck.

These arteries are terminal in children; in adults they anastomose, beginning at the end of the growth period. Thus the typical and constant localization of inflammatory lesions and their occurrence in a certain period of life are easily explained.

ANATOMICAL AND ROENTGENOLOGICAL ASPECTS

In addition to the site, the morphological aspect of the lesions in the early stage of their manifestation aids in demonstrating the intimate relationship between localization and lesion.

Quite frequently the shape of an infarct can be noted in the roentgenogram. The focus is more or less triangular in shape with a wide base toward the epiphyseal plate and the point toward the metaphysis (Fig. 1). This, however, is true only in the beginning of the process when the focus is still well circumscribed. It is especially prominent in tuberculosis because of the chronic and slow character of the disease. It is difficult to demonstrate a wedge-shaped focus in diseases of more acute character with rapid invasion, as in pyogenic lesions (Fig. 4).

In both types of inflammation, pyogenic and tuberculous, the earliest stages yield only a picture of slight spotted atrophy which becomes evident mainly by comparison with the normal side. Although of greatest importance from the therapeutic viewpoint, it is frequently very difficult, purely on the basis of roentgenographic findings, to differentiate the tuberculous lesions from those caused by other organisms. It is generally agreed that the diffuse bony atrophy and the absence of more marked periosteal and endosteal reactions are characteristic of tuberculous lesions, while the opposite picture obtains for pyogenic osteomyelitis. This holds true for the majority of cases but not for all cases.

The main reason for this is that the bony tissue reacts to each bacterial agent in a very different way. Consequently, the roentgenograms show diverse conditions, depending upon the virulence of the germ, the

varying intensity of the disease process, and the different reactions of the organisms. If the tubercle bacillus shows marked signs of virulence and the reaction of the organism is active, as is quite often the case in childhood, then the roentgenogram may reveal features which usually are considered as characteristic of non-specific inflammatory lesions. Furthermore, if we consider that the juxta-epiphyseal lesions are always situated very superficially, even subchondrally, we will understand that elevation of periosteum will occur not only in pyogenic but also in tuberculous lesions, because of the immediate surrounding reaction.

Neither can greater significance from a diagnostic viewpoint be attributed to the precocious formation of sequestra, because they occur in both affections with the same frequency. Thus Case 2 (Fig. 3) and Case 3 (Fig. 4) could, from a roentgenological viewpoint, be attributed to one affection as well as to the other; whereas Case 6, although tuberculous in nature, could have been included in the group of simple osteomyelitic lesions, because of the marked periosteal reaction.

Among the indirect signs of the focus is the frequent expansion of the joint capsule superiorly and inferiorly with restriction of the joint space (Lange). This sign indicates the increase of synovial fluid in the joint cavity caused not by germs but by toxic irritation from the bony focus. The widening of the joint capsule on the upper side of the joint can easily be visualized if the roentgenogram is taken with soft rays and without a reenforcing filter (Figs. 4, 5, and 6).

The inflammatory lesions of the juxta-epiphyseal zone rarely remain circumscribed. As a rule, they break into the hip joint after a shorter or longer period during which they preserve sharp outlines.

The analysis of the different forms of evolution of these lesions is interesting. As in any other localization, the appearance of the focus is followed by a halo of perifocal sclerosis, which in an early stage is weak and only partial. It demarcates the focus and arrests or retards its evolution.

These zones of reaction may gradually become quite marked; this is true not only in the pyogenic forms (Fig. 8) but also in tuberculous lesions (Fig. 3). They vary from case to case and influence the further development of the lesion. Interesting in this respect was Case 4 (Fig. 5) in which an annular band of sclerosis was present immediately around the focus and another band, at a greater distance, involved a large part of the metaphysis. Of even greater interest was Case 5 (Fig. 6). Here, the inflammatory process, on its way to the surface, had formed a tunnel which partially destroyed the epiphyseal cartilage of the greater trochanter and led to the formation of an abscess and a fistula without invading the joint.

The juxta-epiphyseal lesions can be differentiated from others in the immediate vicinity by some peculiarities which are caused by the involvement of the epiphyseal disc. The poorly vascularized cartilage of the epiphyseal plates, rarely directly involved in a disease process, is very sensitive to every toxic or bacterial agency during the period of its greatest activity. Despite the fact that the foci are situated very close to the

epiphyseal line, the process very rarely directly attacks or destroys this area. Case 2 (Fig. 3) showed this remarkable resistance of the epiphyseal cartilage which, although involved in the disease process (as could be seen by its hazy configuration in the roentgenogram), became only attenuated and atrophic during the two years' duration of the disease. Otherwise it appeared to be healthy with a linear and sharp shadow. Proof of its function is found in the facts that the bony segment had continued to grow and that the bony focus had become displaced downward in the metaphysis (Fig. 3, *B*).

The involvement of the epiphyseal cartilage, which is determined with difficulty even by the expert eye and which is perceptible only in technically perfect roentgenograms, is revealed by direct and indirect signs. Among the first of these should be mentioned the contraction of the bony portions which are separated by the plate. However, the chief signs are the haziness and irregularity of its usually clear-cut and distinct linear image (Figs. 2, 3, 4, and 6). Among the indirect signs one of the most constant and important is a bony condensation at the epiphyseal side of the destroyed portion of the cartilaginous plate. This is sometimes very slight and almost imperceptible. These observations were confirmed by autopsy in one case studied at the *Istituto Ortopedico Rizzoli.*

If the alterations of the spongy bone below the epiphyseal plate are marked, and if also the blood vessels from which the epiphyseal cartilage obtains its nutrition by imbibition are involved, important changes in shape will result.

In the following case, which had been under careful observation for years, a gradual slipping of the epiphysis toward the superolateral portion of the neck occurred, leading to a certain degree of coxa vara epiphysaria.

CASE 8. B. M., a girl, eleven years old. In addition to other suppurative lesions, the patient had an involvement of the right hip. The roentgenogram (Fig. 9, *A*) showed complete separation of the epiphysis. Its bony density was slightly higher than normal. The periosteum along the diaphysis was elevated.

Diagnosis: Osteomyelitic focus in the juxta-epiphyseal zone with epiphyseal separation.

Closed reduction was attempted with only partial success, and the hip was immobilized in a plaster spica. Four months later, the hip was still swollen, hot, and painful. The roentgenogram (Fig. 9, *B*) showed the same position of the epiphysis, which appeared dense and sequestrumlike in its upper half. After three more months of immobilization, the roentgenogram (Fig. 9, *C*) revealed that only small sequestrated fragments of the epiphysis remained. A sinus had opened in the groin and was discharging profusely. Hip drainage, with sequestrectomy, was performed. One month later, the incision had healed and the hip was solid and in good position (Fig. 9, *D*).

The functional disturbance which results from juxta-epiphyseal lesions has been discussed on another occasion. Its chief effect is noted on the growth of the extremity which is stimulated in the first period and inhibited in later stages. Also, the development of the cephalic epiphysis may become hastened or retarded according to the stage of the bony lesion.

FIG. 9

Case 8. B. M., a girl, eleven years of age. Osteomyelitic focus in the juxta-epiphyseal zone with epiphyseal separation.
A: May 16, 1934. *B*: August 27, 1934.
C: November 29, 1934. *D*: August 23, 1935.

SYMPTOMATOLOGY AND COURSE

It has been stated before how treacherous and difficult may be the interpretation of the roentgenograms of the juxta-epiphyseal lesions from a diagnostic standpoint. We shall now consider the positive signs which are revealed by physical examination and the characteristic symptoms of each type of lesion.

The limitation of motion, active as well as passive, is an early sign of involvement of the synovial membrane and this symptom should be analyzed with the greatest care. It is almost always related to the bony

lesion and can, therefore, aid in the localization of the bony focus. There always results limitation of that type of motion which causes tension on the periosteum and the joint capsule overlying the inflammatory lesion. For this reason, in some cases in which the joint cavity has not yet become invaded (Cases 4, 6, and 7), the extremity assumes a certain rest position in order to relax the joint capsule over the diseased region.

If the focus is in the inferomedial portion, the leg is kept in adduction, slight flexion, and external rotation. For the most part, these cases show marked limitation of abduction and flexion. In cases with foci in the intermediate portion, there is an obstacle to external rotation and abduction.

Limitation of internal rotation is characteristic in cases with foci in the superolateral portion of the neck. Internal rotation is affected first and in the greatest degree (Cases 4, 5, 6, and 7). Later, and to a minor extent, follows the limitation of flexion and adduction. Pain, due to muscle spasm from periosteal irritation, is a frequent symptom when motion is forced in the direction in which it is mainly limited.

Tenderness on pressure is present over the deep part of the inguinal fold in cases with foci in the inferomedial portion of the femoral neck. In cases with lesions of the superolateral portion, tenderness is noted over the middle point of the spinotrochanteric line.

Palpation furnishes other signs of a more general significance, such as increase of skin temperature, sometimes very slight and transient, and thickening of the joint capsule, which as long as the joint cavity is not invaded is probably due to toxic irritation of the synovia. In one patient (Case 4), deep palpation of the joint gave the impression of dense, elastic consistency, like leather under moderate tension.

Another sign which cannot be overlooked because of its frequent occurrence is unilateral inguinal lymphadenopathy, the presence of which always makes one suspicious of a bony lesion in the neighborhood.

Finally, the hypotonia of the musculature associated with, but almost always preceding, the hypotrophy is a sign of indubitable value in favor of an organic hip lesion.

In a very early stage of the affection, associated with these two factors more than with the pain, is limitation of weight-bearing on the affected extremity, resulting in a very slight limp which is more easily recognized by the ear than by the eye.

In cases with foci of the superolateral portion, the use of the limb for weight-bearing is allowed in slight external rotation (Cases 4 and 5). Among the periarticular muscles the glutei are the most hypotonic and hypotrophic and frequently produce a positive Trendelenburg sign.

Tuberculous lesions, as well as pyogenic osteomyelitic lesions, can manifest themselves by such symptoms. Therefore, the differential diagnosis is very difficult in cases in which the history, biological reactions, and the clinical course do not aid. (See Case 3.)

There are definite cases of simple osteomyelitis which simulate tuberculous lesions, and there are even more frequently tuberculous lesions which

have a clinical picture and course that commonly are considered as typical of acute and subacute pyogenic osteomyelitis.

The author wishes to consider here some details which have not been mentioned by other writers who have occupied themselves with the subject. It frequently happens after trauma that a tuberculous lesion develops, accompanied by high fever, redness, swelling, increase of local temperature, marked limp, rapid decline of the general condition, and inability to bear weight. Such was the clinical picture in Cases 5 and 6. Case 5 was proved to be tuberculosis by the appearance of sinuses and other skeletal lesions, by the biological reaction, and by the clinical course. The juxta-epiphyseal lesion remained localized in the cancellous bone of the neck. The acute clinical picture with which this affection was associated cannot, therefore, be explained as a sudden invasion of the joint cavity. The same is true of Case 6, which also was complicated by the appearance of sinuses and the destruction of the joint ends. It, nevertheless, was a case of simple tuberculous osteo-arthritis in which the focus remained circumscribed for a period of at least six months.

It may be mentioned finally that, if there is lacking sufficient evidence of an endocrine influence, it is possible to confuse an idiopathic epiphyseolysis with a tuberculous or osteomyelitic lesion.

TREATMENT

The greatest exactness of diagnosis is necessary, not only in a general way, but also as to localization and to the stage of the development. This is of great practical importance because the treatment of pyogenic osteomyelitic lesions has to be conducted in a different way from that of tuberculous lesions, the treatment of which depends upon the stage of evolution.

In lesions caused by pyogenic organisms, surgical treatment is frequently absolutely necessary to obtain a good anatomical and functional result. In the initial stages with moderate virulence, the routine conservative treatment may be sufficient,—that is, traction followed by immobilization of the diseased joint (Case 3). As in tuberculous lesions, so also in these cases spontaneous regression and healing may occur, although not very frequently.

In other instances surgical treatment may give brilliant results, as in Case 7, in which the intervention was performed at the right moment and the hip was saved from the imminent invasion. Healing occurred with almost complete motion which still persists five years after the onset of the disease.

These are the cases in which surgery is the treatment of choice. However, there are also other cases in which operation is indispensable, such as Case 8 in which the epiphysis, separated from its source of nutrition, became absorbed on one side and sequestrated on the other. Due to the suppuration maintained by the sequestra and the inability of the limb to bear weight, surgical intervention became necessary.

As far as the tuberculous lesions are concerned, the author has discussed them on other occasions and wishes to mention only those points which have been brought out by the cases described. Conservative treatment, if instituted early and conducted well, is the only treatment capable of giving good results in these cases. This is the frequently expressed opinion of the writer's teacher, Prof. Putti, which is based upon his long and extensive experience. Of the fifteen cases which the author has studied and treated by immobilization in the *Istituto Rizzoli*, cure has been obtained in six cases. Cure by surgery is possible, but is usually illusory and frequently ephemeral, especially if the follow-up examination is made a number of years after operation. The author has seen patients, who had been operated upon and considered cured by their surgeons, *enter the hospital with a fully developed panarthritis. The reasons for the bad results are multiple, and, since much has already been written* in regard to them, they will not be discussed here.

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THE END RESULTS OF THE FRACTURED DISTAL TIBIAL EPIPHYSIS

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There seems to be a great difference of opinion as to the end results of fractures of the epiphyses. We apparently know little about such injuries, although their occurrence is by no means rare. In discussing this subject, most writers have considered fractures of the epiphyses as a group. We believe that we can no more classify all epiphyseal fractures in one group, as to end results, than we can classify the end results of fractures of the clavicle with those of the os calcis. This fact is obvious when one recalls that the epiphyses vary greatly in their anatomical structure and physiological function. Furthermore, the location of an epiphysis determines to a great extent its susceptibility to injury. Such factors as size, shape, and position of the epiphysis, the amount of growth which the epiphysis contributes, and weight-bearing are all of importance. To arrive at accurate conclusions, then, we must consider each epiphysis individually.

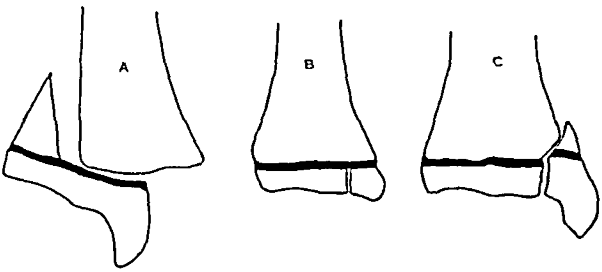

FIG. 1

Diagrammatic drawing showing usual types of fractures:
A: Type 1. The fracture line runs parallel and proximal to the cartilage plate (heavy black line) through the newly formed bone and emerges through the shaft. There is no fracture of the cartilage plate itself. The entire epiphysis is displaced *en masse*.
B: Type 2. The fracture line crosses the bony epiphysis from the joint to the cartilage plate, but there is no fracture through the plate. In about 40 per cent. of the cases the plate is crushed.
C: Type 3. The fracture line runs through the bony epiphysis, the cartilage, and the shaft.

In order that our conclusions may be accurate, we must have accurate statistics. A review of the literature shows that this prime requisite has been overlooked. In most instances the authors have reported a small series of cases which they have followed for a time. To these they have usually added several cases of deformity which have come to their clinics from suburban or rural districts. A high percentage of poor end results is thus obtained. It should be obvious that we cannot get a true picture of end results if we add to our series only the poor results which have come from another source. Although our series is not large, it is presented with the hope that others will investigate this subject and furnish accurate statistics on the true results of these injuries.

At the Boston City Hospital, a series of twenty-one cases of fractured distal tibial epiphyses have been studied. These patients have been

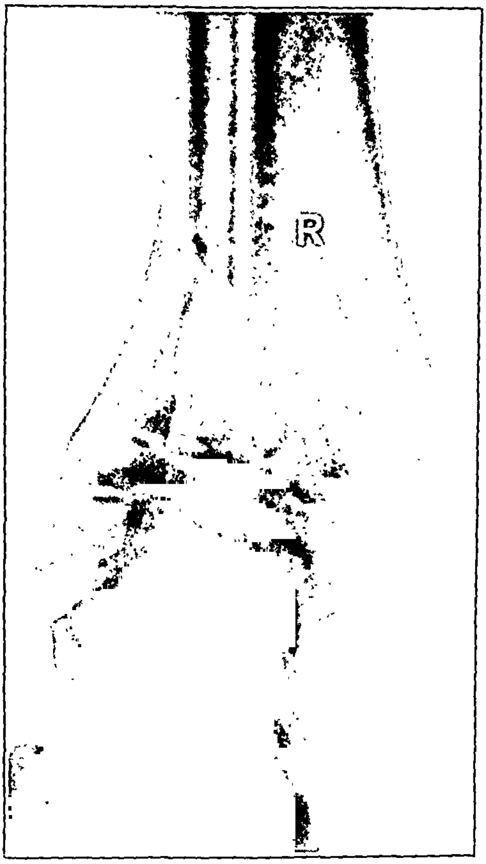

FIG. 2-A

Marked displacement in a patient fifteen years of age. This was incompletely reduced.

reexamined at periods of from two to ten years from the date of injury. There were two female and nineteen male patients. The ages varied from six to sixteen years. There were four cases in which the patients were nine years of age or younger. The majority of cases occurred between the eleventh and the fifteenth years. In this group there were sixteen cases.

In a study of end results, we must not only consider each epiphysis individually, but we must also bear in mind that each epiphysis is subject to different types of fractures, the end results of which vary greatly. In this series, we have found that the distal tibial epiphysis is subject to three distinct types of fractures, the end results of which differ considerably. In order to understand these fractures, it is necessary to consider the epiphysis as consisting of three distinct layers,—the bony epiphysis, the cartilaginous plate, and the layer of newly formed bone between the cartilage plate and the shaft proper.

In the first type (Figs. 1, *A* and 2-A), the fracture line runs parallel and proximal to the epiphyseal cartilage through the newly formed bone. There is usually a chip fracture of the shaft, but no fracture of the epiphysis itself can be seen by x-ray. The epiphysis is thus shunted off *en masse* with little or no damage. This type is the most common and usually shows the greatest displacement.

In the second type (Fig. 1, *B*), the fracture line crosses the bony epiphysis from the joint to the cartilage plate. There is no fracture of the shaft and usually there is very slight, if any, displacement. In our cases the line apparently did not cross the cartilage; consequently the epiphyses suffered little or no damage. McFarland, however, states that in 40 per cent. of his cases of this type of fracture the plate was crossed and deformity resulted. We believe this figure to be more accurate, as it is derived from a larger series than ours.

In the third type (Figs. 1, *C*, 3-A, 4-A, and 5), the fracture line enters the epiphyseal cartilage from the joint, crosses the cartilage, and penetrates the shaft. Displacement is usually slight. In our series, the fracture line was seen on the medial side of the epiphysis. In this type

FIG. 2-B

Same patient shown in Fig. 2-A, two years later. Note absence of deformity. There is, however, some thickening as compared with the opposite side.

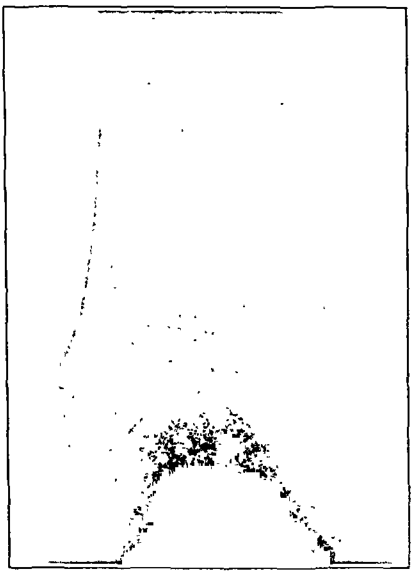

FIG. 3-A

FIG. 3-B

Fig. 3-A: Type-3 fracture. This was not reduced.

Fig. 3-B: Same patient shown in Fig. 3-A, three years later. Note correction of displacement and absence of deformity, but evidence of retardation of growth at fracture site.

FIG. 4-A FIG. 4-B

FIG. 4-A: Type-3 fracture. Roentgenogram after osteotomy for varus deformity. (Operation performed by Dr. Joseph Shortell of Boston City Hospital.) Note evidence of old fracture lateral to internal malleolus.

FIG. 4-B: Roentgenogram taken five years later than Fig. 4-A, showing excellent result.

of fracture the cartilage plate is not only fractured, but in most cases it is crushed.

Of the first type of fracture, there were sixteen cases. In ten of these the displacement was associated with fractures of the shafts of the tibia and the fibula. In two instances the fibula only was fractured, while in four cases the epiphysis was displaced without fracture of either shaft. The type of displacement varied. In most cases displacement occurred laterally downward. In other cases the epiphysis was displaced either medially or anteriorly or posteriorly. In twelve of these cases there was some displacement on discharge from the hospital. In none of these cases can displacement be seen at the present time, nor is there any evidence of deformity. In eight cases, ossification is already complete. In two cases, in which the patients are sixteen and eighteen years of age, ossification is nearly complete. In six cases ossification has not yet begun.

The youngest patient in the latter group is twelve years of age, and it is now six years since his injury. Also in this group are two cases of two years' duration in patients sixteen and seventeen years of age who are near the age of normal ossification. In the remaining three cases the patients are over fifteen years of age, and it is three years or more since the date of injury. It is highly improbable, then, that deformity will occur at this late date in those cases in which ossification has not yet taken place.

Because of the difficulty of including the whole lower leg in a roentgenogram, we have not been able to measure accurately our patients for shortening. Although some undoubtedly have some slight shortening, this cannot be detected clinically in any of the cases.

As we found in our study of the distal radial epiphysis, premature ossification does occur. In two cases the injured epiphysis has already ossified, while the epiphysis of the opposite side has not yet completely closed. We believe that in the great majority of cases of this type of fracture this premature ossification is of little clinical significance.

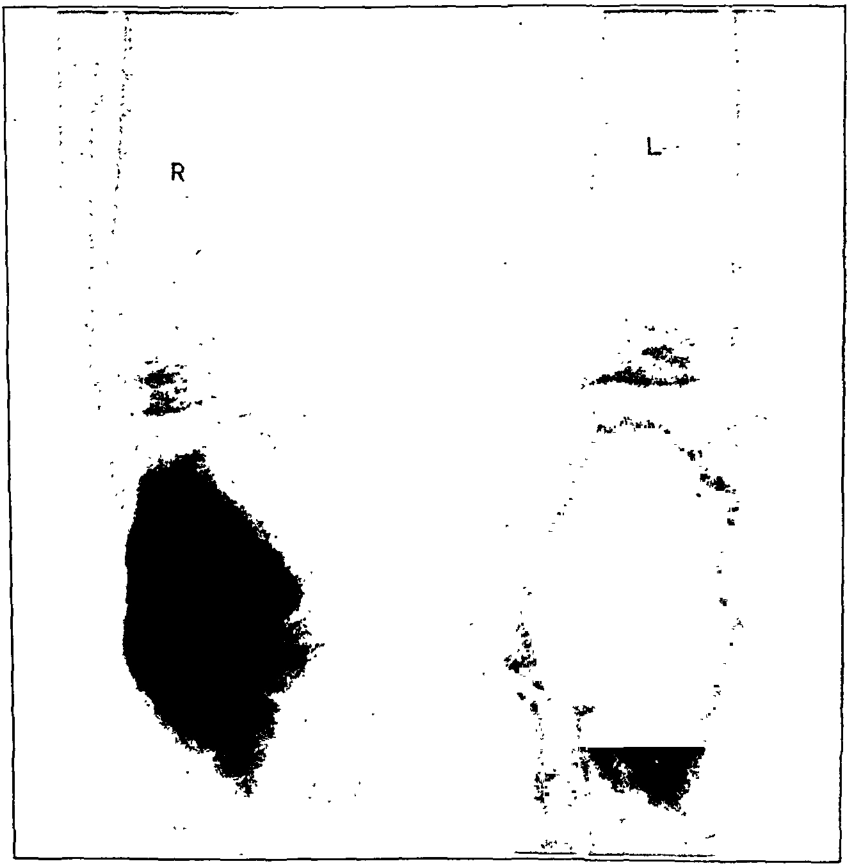

FIG. 5

Patient had Type-3 fracture. Roentgenogram shows ossification of medial third of the epiphysis and developing varus deformity nine months after injury. (Case of Dr. F. J. Cotton.)

In the second group of fractures there were three cases. One of these patients had a fracture of the lateral quarter of the bony epiphysis with displacement, but without fracture of the shaft. In this case the epiphysis is now ossified without deformity, but some lateral displacement can still be seen. There has been no interference either with growth or with function. Two patients had fractures of the medial third of the bony epiphysis without fracture of the shaft. In one of these cases the epiphysis is now ossified; in the other, that of a boy eleven years of age, the fracture is of two years' duration. In neither case is there deformity, clinical shortening, or evidence of retardation of growth at the fracture site.

Of the third type, there were two cases. In one of these the whole fragment was displaced *en masse* medially and upward (Fig. 3-A). An attempt at reduction failed, but no evidence of displacement could be seen three years later (Fig. 3-B). There was no shortening and no deformity, but growth had been definitely retarded at the fracture line. This patient is now fifteen years of age and the epiphysis will probably ossify before deformity can develop. The second patient had a similar fracture, but in this case the typical varus deformity (Fig. 4-A) developed. Shortening amounted to about one and one-half inches. A useful ankle was obtained by osteotomy after the epiphysis had ossified. (See Figure 4-B.)

There were two additional cases of deformity, which, however, do not belong to this series, as they were private cases of Dr. F. J. Cotton. These patients had medial fractures of the shaft and epiphysis into the joint (Fig. 5), and in each case varus deformity developed within a few months of the date of injury.

The fractures in these cases of deformity, we believe, were due to forced inversion. The cartilage plate is thus crushed between the bony epiphysis below and the shaft above. In our opinion, this crushing is the prime factor in the causation of deformity. The distal tibial epiphysis contributes considerably to the length of the leg, and, due to its location, it is subject to such forced inversion injuries. Deformity, due to fracture, is therefore more common here than in any other epiphysis. It may also be true that too early weight-bearing upon such an injured epiphysis is another factor.

CONCLUSIONS

1. In discussing the end results of epiphyseal fractures, each epiphysis must be considered individually.
2. The distal tibial epiphysis is subject to three types of fracture. In the first type, there is little or no damage to the cartilage, and deformity is consequently rare. In the second type, the cartilage is crushed in about 40 per cent. of the cases, with resulting deformity. In the third type, the cartilage is crushed and deformity is to be expected.
3. Malposition of the epiphysis, *per se*, is not a cause of deformity.

As we found in our study of the distal radial epiphysis, any displacement of the epiphysis is corrected by nature within a few months of the date of injury. We believe that in all cases the fracture should be reduced as accurately as possible. However, if complete reduction cannot be obtained, we believe it is wiser to allow Nature to further correct the displacement as she does than to subject these patients to osteotomy.

In summarizing our work on the epiphyses to date, we are convinced that deformity is due only to crushing of the epiphysis at the time of the injury or during osteotomy for correction. If an epiphysis has been so crushed, it is not humanly possible with our present knowledge to prevent the inevitable deformity. If the epiphysis has not been crushed, it will continue to grow normally, although alignment after repeated attempts at reduction may be poor.

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INDICATIONS FOR AND AGAINST THE LEG-LENGTHENING OPERATION

Use of the Tibial Bone Graft as a Factor in Preventing Delayed Union, Non-Union, or Late Fracture*

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Inequality of leg length, resulting from shortening of one leg, is not necessarily sufficient indication for advising a lengthening operation. Shortening of not more than one and one-half inches may be compensated for by tilting the pelvis. If the shortening exceeds one and one-half inches, the surgeon must decide whether or not a better result can be obtained from lengthening the short leg or from shortening the well leg. The well leg may be shortened by one of two methods: resection of a segment of the femur, or the arrest of growth of one or more of the epiphyses of the normal extremity. The surgeon should keep in mind the fact that his responsibility is to equalize the length of the two legs. A major operation designed for the purpose of increasing the standing height of the patient should be condemned. Complications resulting from attempts to lengthen legs without recognition of some of the contra-indications have resulted in leaving some patients more crippled than before the operation. The following case reports illustrate some of these complications and the lessons which the author has learned from them.

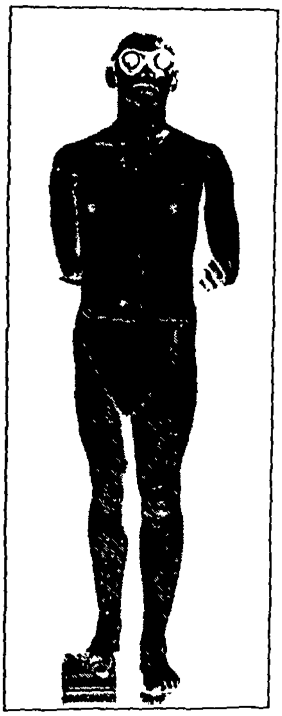

Fig. 1

Case 1. W. K., male, aged seventeen years. Shortening of the right leg as a result of growth arrest from the proximal epiphysis of the right femur.

Case 1. W. K., a male, aged seventeen years, was admitted to the hospital for treatment of inequality of leg length. The right leg was two and one-quarter inches shorter than the left. Growth arrest had followed epiphyseolysis of the capital epiphysis of the right femur at the age of twelve years. Operations had been performed to correct an adduction-flexion deformity of the hip and genu valgum of the knee. The standing height of the patient was five feet, ten and seven-eighths inches. (See Figure 1.) An osteotomy for lengthening the right femur was performed. Double skeletal traction was applied with the leg supported on a Braun frame, as described by Putti. The desired lengthening was obtained, but angulation of the fragments and malunion resulted. At the end of five months, a minimal amount of callus and ossification was present (Fig. 2). There was paralysis of the external popliteal nerve with toe-drop and anaesthesia over the dorsum of the foot.

Shortening of the well leg by resection of a segment of the left femur would have been a safer procedure. The patient refused to permit the shortening operation and, since the short leg was

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sound, strong, and free from any pyogenic infection, lengthening was thought to be a justifiable procedure.

Complications included delayed union and malunion. Angulation resulted from poor control of the fragments and inadequate splinting while traction was applied. The paralysis was due to stretching of the external peroneal nerve.

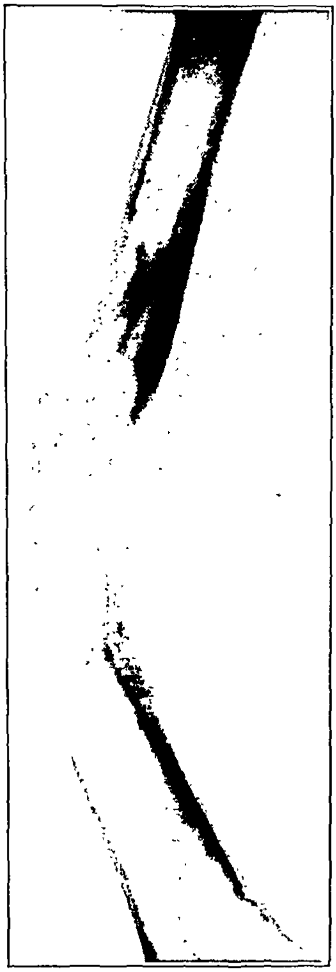

FIG. 2

Case 1. W. K. Roentgenogram showing poor union and malposition five months after the osteotomy.

CASE 2. L. M., a female, aged fifteen years, was admitted to the Orthopaedic Hospital at the University of Chicago Clinics for lengthening of the left femur in January 1932. The standing height of the patient was five feet, one inch. Growth of the proximal epiphyses of the tibia and fibula had been arrested, following an attack of acute osteomyelitis, and the left leg was three and one-half inches shorter than the right (Fig. 4-A). The shaft of the femur had not been involved by the infection. An operation to lengthen the short femur was advised.

The periosteum of the femur was elevated for a distance of about seven inches. A Z-shaped osteotomy, six inches in length, was performed. During the operation one of the osteotomy fragments fractured and was tied to the shaft. Good alignment was maintained during the initial period of traction, but, after about two inches of lengthening had been obtained, there was separation of the fragments (Fig. 3). One month after the first operation, a full-thickness segment was removed from the right tibia and was placed as an onlay graft across the defect in the femur. Seventeen days after the second operation, the patient began to complain of pain over the upper portion of the healed wound. One month after the second operation, the temperature suddenly rose to 40 degrees centigrade, and the wound became swollen and red. Pus, from which hemolytic streptococci were cultured, was expressed when the wound was incised. Bone union occurred, but, during the year following this operation, a number of sequestra were removed. The patient now has a fibrous ankylosis of the knee with only a few degrees of motion. A sinus intermittently drains a few drops of purulent material. (See Figure 4-B.)

Since this patient was a young woman with a total height of five feet, one inch, and since there had been multiple osteomyelitic foci, the operation of choice would have been that of shortening the right femur. Average standing height of a patient is far less important from the standpoints of function, gait, or appearance than is equality of leg length.

The complication of fracture of the osteotomy fragment could have been avoided by making drill holes along the line of osteotomy before inserting the chisel, and an oblique osteotomy would have created less weakness where the fragment joined the shaft. Periosteum was stripped

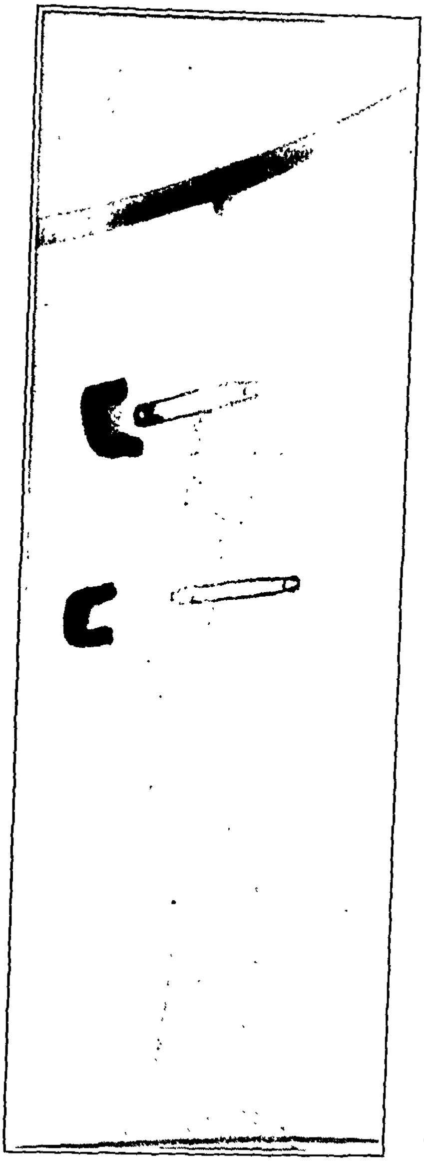

FIG. 3

Case 2. L. M., female, aged fifteen years. Roentgenogram showing fracture of the distal osteotomy fragment with more than one inch of separation.

FIG. 4-A

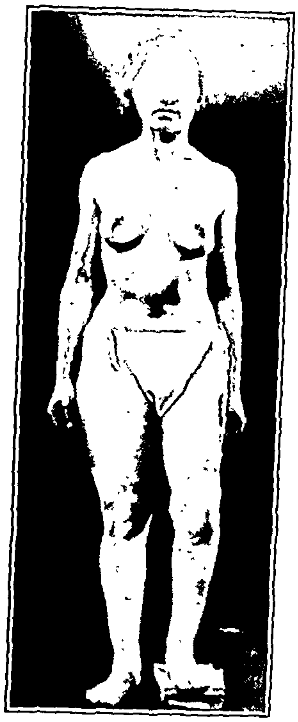

FIG. 4-B

Fig. 4-A: Case 2. L. M. Before operation, showing shortening of more than three inches. The scar above the knee represents the site of an osteotomy for correcting genu-varum deformity.

Fig. 4-B: Case 2. L. M. Two years after operation, showing that two inches of lengthening has been obtained. There is almost complete fibrous ankylosis of the knee. The patient still has more than one inch of shortening. Such a result does not justify the operation.

more widely than the author now considers advisable and this, together with further devascularization necessitated by a second operation one month later for insertion of the bone graft, led to aseptic necrosis, breaking down of the wound, and secondary infection.

CASE 3. J. K., a female, aged eighteen years, was admitted to the Orthopaedic Hospital of the University of Chicago Clinics, October 26, 1934. Ten years previously a pyarthrosis of the right hip and the right knee had resulted in ankylosis of the knee, deformity of the hip, and premature closure of the epiphyses of this bone. The right leg was three and one-half inches shorter than the left. The sinuses near the hip and the knee had been healed for from seven to eight years, and the shaft of the femur had at no time been grossly involved by the infection. The total standing height of the patient was four feet, eight inches. (See Figure 5.)

After the periosteum had been stripped for a distance of about ten inches over the middle and lower thirds of the short femur, a Z-type of osteotomy was done. A full-thickness tibial bone graft was obtained and attached to the lower fragment, so that it overlapped the osteotomy. One month after operation the roentgenogram showed a fracture of the distal fragment of the Z osteotomy with one-half inch of separation (Fig. 6-A). The tibial bone graft which had been applied did not overlap sufficiently to

FIG. 5

Case 3. J. K., female, aged eighteen years. Shortening of the right leg and ankylosis of the knee. Note multiple scars from healed sinuses both above and below the knee joint.

FIG. 6-A

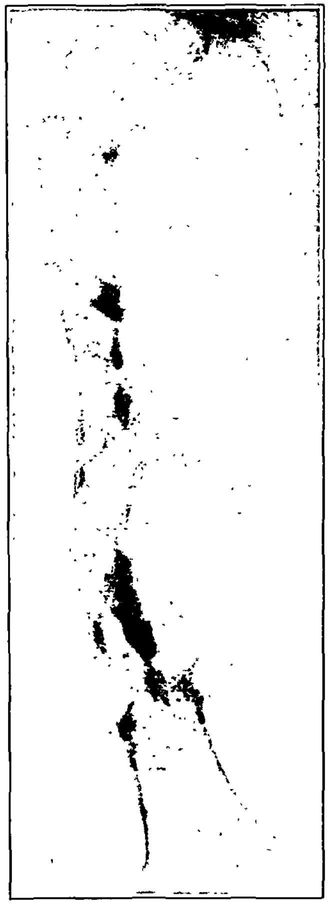

FIG. 6-B

Fig. 6-A: Case 3. J. K. Roentgenogram showing the long Z-type of osteotomy, the distal fragment of which fractured after traction had been applied, with the resultant loss of continuity throughout a distance of almost one centimeter.

Fig. 6-B: Case 3. J. K. Roentgenogram showing grossly infected and deformed femur with non-union of the fracture at the site of the osteotomy.

bridge this defect. Traction was removed and the bone fragments were allowed to approach each other. Approximately eight weeks after operation, a sinus developed in the operative incision and frank pus was discharged. Drainage has continued and on two occasions sequestra have been removed. At the present time there is no bony union, although a moderate amount of involucrum has formed (Fig. 6-B). As a result of the removal of the traction following the fracture and the loss of bone from sequestration, the femur is shorter today than it was before leg-lengthening was attempted.

In retrospect, we are able to say definitely that this was not a suitable case for the leg-lengthening operation, since silent foci of pyogenic organisms are known to be retained in living bone for long periods of time. Errors in operative technique included: making an incision longer than was necessary for the lengthening desired, extensive stripping of periosteum throughout more than half of the length of the femur, use of the Z-type of osteotomy, and failure to attach the tibial bone graft so that it

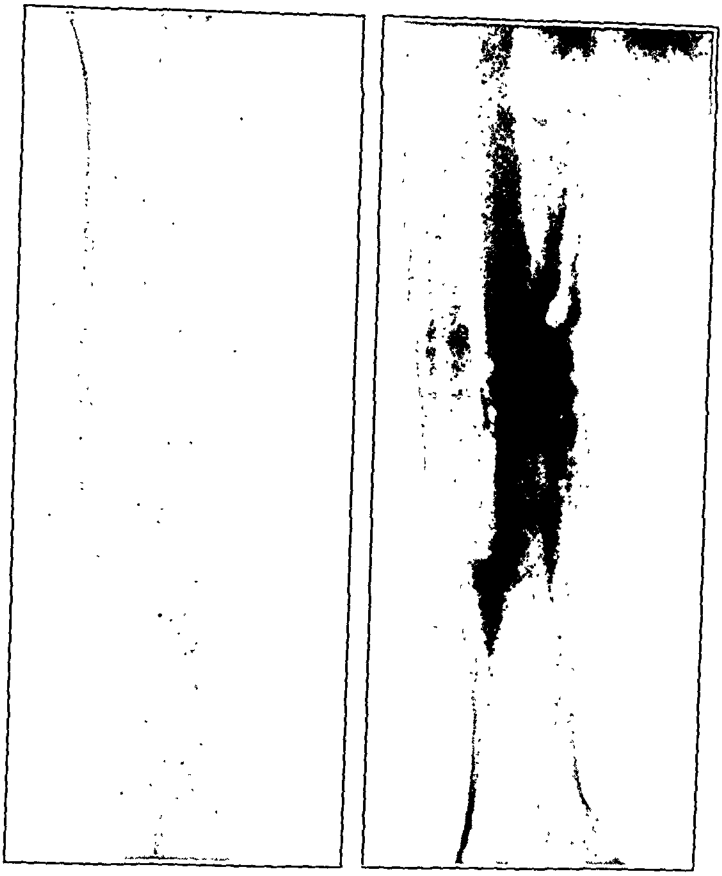

Fig. 7-A

Fig. 7-B

Case 5. I. M., male, aged fourteen years. Roentgenograms taken five months and one year, respectively, after operation. They show an adequate amount of involucrum with firm bony union. The osteotomy fragments have retained their density and drill holes and saw-cut margins of the osteotomy fragments are clearly defined, indicating devitalization.

definitely overlapped the weakened zone. It is probable that aseptic necrosis occurred as a result of the devascularization of more than half of the shaft of the femur, and this led to sequestration and later suppuration. It would have been more advisable to have shortened the long leg, even though this reduced the standing height of the patient to less than four feet, six inches.

Case 4. P. P., a male, aged seventeen years, entered the Orthopaedic Hospital at the University of Chicago Clinics, May 2, 1935, for lengthening of the right tibia and fibula. The right leg was three inches shorter than the left as a result of osteomyelitis which began in the right femur in 1927 when the patient was ten years of age. Growth arrest of both the distal and proximal epiphyses of the femur had occurred. In February 1932, the lower femoral and upper tibial and fibular epiphyses of the left leg were operated upon to arrest the growth. At the time of these epiphyseal arrests, the patient was fourteen years and five months of age and the difference of length of the legs was three inches. This operation prevented an increase in the shortening.

When the patient was brought into the hospital for the proposed lengthening of the tibia and the fibula of the right leg, his total standing height was five feet, four inches. An oblique osteotomy was performed in the right tibia and fibula—bones which had not been involved by the previous osteomyelitic infection and which roentgenographically were quite normal—and an onlay graft, removed from the left tibia, was attached across the defect. The patient stood the operation well, but there was an immediate rise of temperature which persisted. Suppuration developed, followed by septicaemia, gangrene, pulmonary embolism, and death.

The history of osteomyelitis in an extremity should preclude any plan to lengthen any bone of that extremity.

Case 5. I. M., a male, aged fourteen years, sustained a fracture of the right femur at the age of seven years and this resulted in growth arrest of the distal femoral epiphysis. When admitted to the University of Chicago Clinics, he was fourteen years of age and

FIG. 8-A

Case 5. I. M. Sequestrated osteotomy fragments after excision. Note the sharply defined saw and drill cuts with some evidence of absorption at the extreme ends.

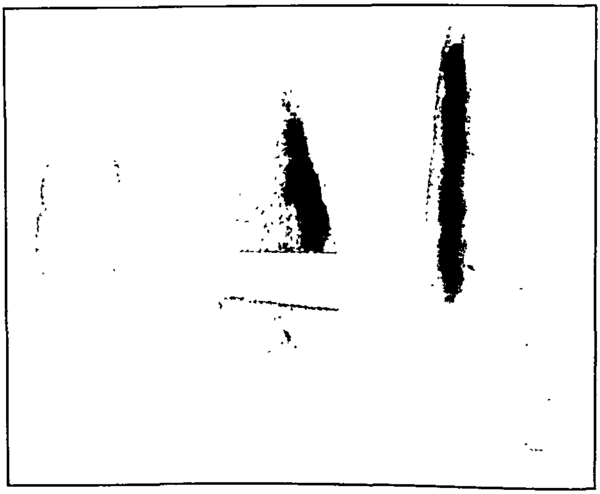

FIG. 8-B

Case 5. I. M. Roentgenogram of specimen showing density well preserved and the clear lines of the cut surfaces and drill holes.

stood five feet, two inches in height. The right leg was two and one-quarter inches shorter than the left, and roentgenograms showed that longitudinal growth had been largely completed, since the epiphyses of both lower extremities were now fused to the metaphyses. The patient was psychologically disturbed because of his short stature, and surgical shortening of the well leg, which would reduce standing height to about five feet, was thought to be inadvisable.

On November 6, 1934, an operation was performed preparatory to lengthening the right femur. The periosteum was stripped from the femur for a distance of about ten inches. A long oblique osteotomy was performed. A tibial bone graft was tied to the proximal fragment. The wound healed *per primum*. Two and one-quarter inches of lengthening was obtained by means of the traction. On December 1, 1934, twenty-five days after

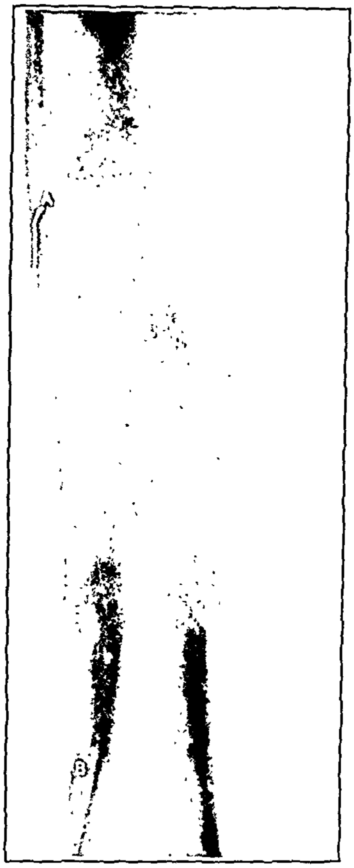

FIG. 9

Case 5. I. M. Roentgenogram of the femur thirteen months after successful lengthening of two inches and after excision of the sequestrated osteotomy ends. A small draining sinus still persists. The tibial bone graft *AB* was found to be viable throughout its length and firmly united, bridging the zone of lengthening.

the operation, the wound opened and purulent drainage followed. Union occurred, but subsequent roentgenograms (Figs 7-A and 7-B) showed gradual sequestration of the osteotomy fragments. Motion in the knee at the time of the removal of the cast was limited to about 10 degrees. On December 20, 1935, the sequestrated ends of the osteotomy fragments of the femur were removed (Figs. 8-A and 8-B). The tibial bone graft, however, was found to be viable and firmly united (Fig. 9).

DISCUSSION

A review of the reported cases of leg-lengthening operations shows that every surgeon who has attempted this formidable procedure has had some complications. Interest in the successful cases has sometimes detracted from the lessons that could be learned from the failures. No surgeon has attempted to list in detail the indications for or contra-indications to this operation and none has specifically emphasized the complications or failures which he has experienced. Complications in femur lengthening are more common than those which may occur when the tibia and fibula are lengthened.

In the series of femur lengthenings reported by Putti in 1921 and 1934, protocols of individual cases were omitted, but delayed union was the rule rather than the exception.

Abbott and Crego reported late fractures, angulation, and malunion of fragments and infection at the site of the pin insertions in some of their first eight cases of femur lengthening. In 1932 Abbott reviewed his entire series of forty-eight lengthenings of the tibia and fibula and twenty-five femur-lengthening operations. In seven of the twenty-five cases of femur lengthening there were late fractures. There were three cases of paralysis of the peroneal nerve, two of osteomyelitis at the osteotomy site following operation, and many less serious infections at the site of the insertion of the pin through an incision on the medial side of the thigh near the groin. Abbott stated in 1932: "In lengthening of the femur . . . we have experienced great difficulty in devising apparatus which will maintain alignment of the fragments."

Haboush and Finkelstein have quite frankly discussed their difficulties in lengthening the tibia and fibula. In their series reported in 1932 there were six cases of postoperative osteomyelitis, four of delayed union, and one case of non-union. Other complications included one deformity

of the foot, one fracture of the osteotomy fragment, and angulation in nearly all cases.

In 1935, in addition to describing similar complications in his series of forty-six leg-lengthening operations, Brockway stated that in a number of patients operated on during the growth years the lengthened leg was again one inch or more short at maturity.

The author has reported unsatisfactory results in five cases of leg lengthening and has emphasized complications. He has learned more from these cases than from those in which lengthening was obtained with less difficulty or with fewer complications.

The following complications have been encountered in cases in which leg-lengthening operations have been performed:

1. Stretch paralysis of the sciatic or the external popliteal nerve.
2. Increased weakness of lengthened muscles in old cases of poliomyelitis.
3. Fracture of the osteotomy fragment.
4. Malunion.
5. Delayed union or non-union.
6. Osteomyelitis from wound infection or lighting up of a silent bacterial focus.
7. Traumatic arthritis and limitation of motion in the knee.
8. Late fracture.
9. Pressure or stretch necrosis of the skin in the zone of lengthening.
10. Necrosis of bone due to excessive subperiosteal stripping. This may increase the likelihood of infection.
11. Malposition of the foot due to rotation following lengthening.
12. Circulatory disturbance with prolonged oedema in the lengthened limb.
13. Displacement of the head or of the distal end of the fibula when this bone is not lengthened as much as is the tibia.
14. Protrusion of the osteotomy fragment of the tibia through the skin.

Hey Groves has continued to advocate leg shortening as the operation of choice for many types of cases of inequality of leg length. He says: "The short leg in these cases (healed tuberculosis of the hip or infantile paralysis) is nearly always undernourished, with poor blood supply, weak muscles, and slender bones. . . . As the limb is therefore ill adapted to plastic operations, it is much wiser, in my opinion, to shorten the sound leg rather than attempt to lengthen the weak one."

The normal femur may be safely shortened by 25 per cent. of its total length. Hey Groves has added: "It is very remarkable how the slack of four inches of muscle is taken up within a few months and the full muscular power of the leg regained."

Camera has used this operation twenty-one times in children with good results.

An analysis of the author's cases and of those reported by others

enables him to list the following conditions which would cause him to advise against leg lengthening and to advocate shortening of the well leg if the discrepancy in leg length is great enough to justify operation. Contra-indications to leg lengthening are as follows:

1. Shortening of less than three centimeters.
2. Age of patient under fifteen or sixteen years.
3. Any patient who is sufficiently tall to permit shortening the longer leg or who will not be psychologically disturbed because of loss in standing height by:
   a. Epiphyseal growth arrest, or
   b. Resection of a segment of the femur of the long extremity.
4. Weak or paralyzed muscles of the hip or knee.
5. Shortening so marked that maximum lengthening will not sufficiently equalize the extremities to enable discarding of shoe elevation or other appliance.
6. History or clinical and roentgenographic evidence of previous osteomyelitis in the short leg, or other pathology in the bone to be lengthened,—*i.e.*, fibrocystic disease.
7. Congenital short leg, as in absence of part of the bone to be lengthened, or other severe deformities in which an artificial limb may give a better functional result.

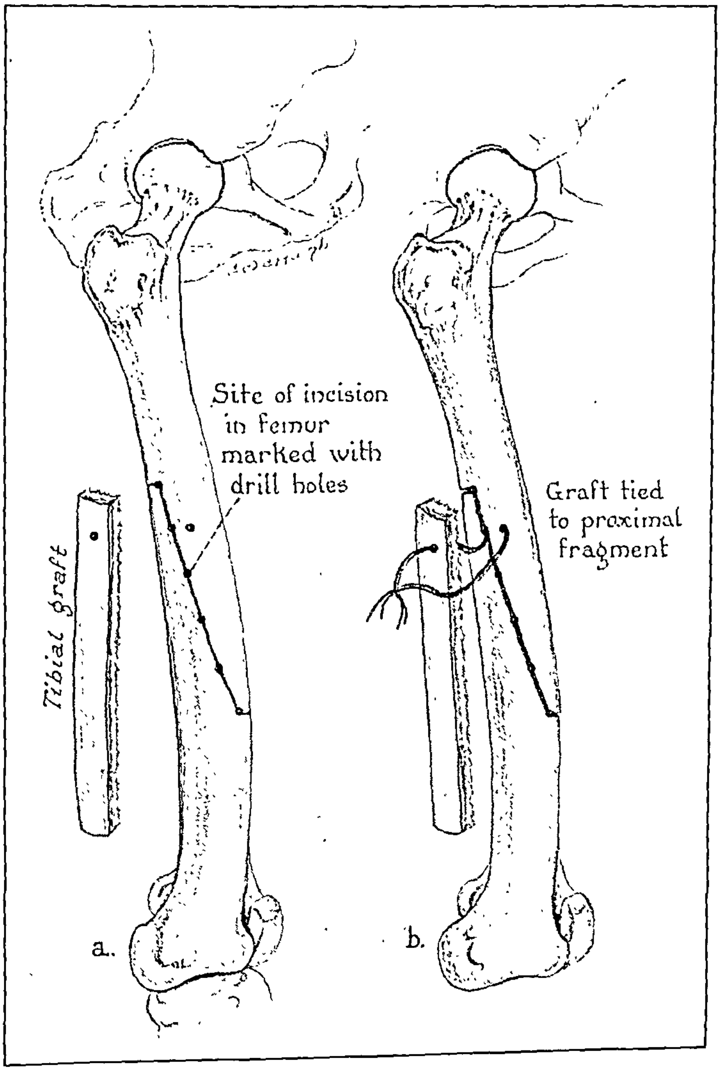

Fig. 10-A

Diagrammatic illustration of the type of osteotomy which the author's experience has led him to adopt, showing the tibial bone graft being applied.

Phemister has demonstrated that inequality of leg length in the growing boy or girl may, in suitable cases, be corrected by the surgical fusion of the lower femoral epiphysis, the upper or lower tibial and fibular epiphyses, or a

combination of two or all three of these epiphyses, to their respective metaphyses.

This is a simple operative procedure and entails little risk to life or limb. In the University of Chicago Clinics more than 100 epiphyseal-arrest operations have been performed on seventy patients without any complications and with preservation of complete and normal function in the well leg subjected to this operation. In no instance has growth of the well leg been inhibited so much that the originally short leg became the longer of the two.

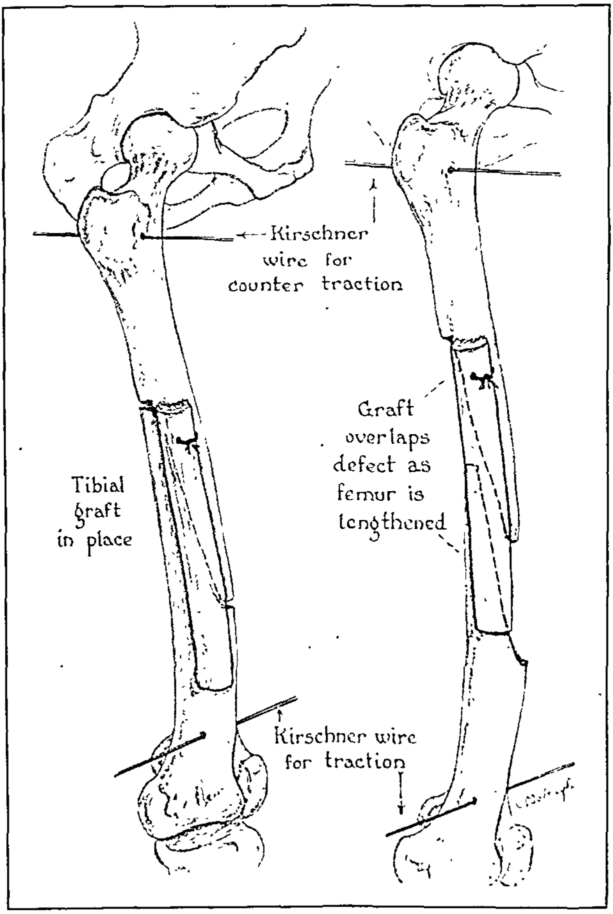

Fig. 10-B

Tibial bone in place as an onlay graft, both before and after lengthening has been obtained, illustrating the splinting effect and advantage in obtaining more rapid and stronger bone union.

Harris has reported that excision of the lumbar sympathetic rami and ganglia on the side of the paralysis may stimulate growth in the short limb. Bisgard found no increase in length growth of an extremity following lumbar sympathectomy on young goats and monkeys. Arrest of epiphyseal growth by means of roentgen irradiation has been successfully accomplished in experimental animals, but the procedure is not yet considered to be well enough standardized to be recommended for young children.

Although complications of the leg-lengthening operation have been common and the author has enumerated a number of contra-indications, there are selected cases in which he recommends the operation and considers that the risk to life or limb may be justified. Indications for leg lengthening are as follows:

1. Shortening of more than one inch that produces impairment of gait.

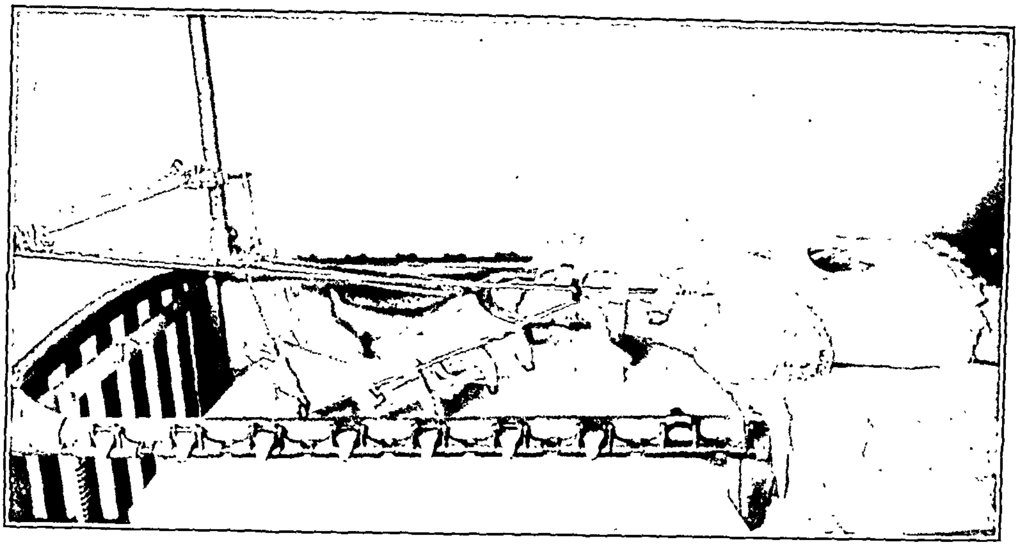

FIG. 11

Illustrating the method of applying the modification of the Hoke type of skeletal traction which, in the author's experience, has afforded satisfactory control of the fragments.

2. Young adult or adolescent patient.

3. Good to normal muscle power at hip and knee and a stable foot, or one that can be stabilized surgically.

4. Absence of previous infection of bones of the short extremity.

5. Refusal of patient to permit, or other contra-indication to, shortening of the longer leg.

The lessons learned by the author from the errors in judgment or technique which led to the complications described in the preceding report of five cases of leg lengthening have enabled him to adopt a plan of operation which includes safeguards and principles that may be of some help to others.

The methods of operative lengthening of the tibia and the fibula have been standardized by Abbott and Crego, Haboush and Finkelstein, and Moore and successfully applied with slight modifications of apparatus or technique by many other surgeons throughout the world.

THE TIBIAL-BONE-GRAFT TECHNIQUE OF FEMUR-LENGTHENING OPERATION

Lengthening of the femur has usually been performed by some modification of the oblique osteotomy of the midshaft, followed by skeletal traction as described by Putti in 1921. Putti's patients were unable to bear weight on the limb which had been operated upon until nine to fifteen months after operation. The writer's experience with leg lengthening has resulted in the adoption of the following plan of operation:

1. A Kirschner wire or Steinmann pin is inserted anteroposteriorly through the trochanter.

2. An elastic bandage is applied from toes to groin to drive the blood from the limb.

3. An Esmarch bandage is then applied above the pin as a tourni-

quet and the elastic bandage is removed from the leg. The thigh is prepared with iodine and draped.

4. A posterolateral incision is made and the femur is exposed by separating the muscles from the lateral fascial septum.

5. The periosteum is stripped only as far as the length of the osteotomy, to avoid devascularizing the bone.

6. An oblique rather than a Z-type of osteotomy is used, as there is less danger of fracture. This cut may be made through the outer cortex with the motor saw.

7. The osteotomy should be only about two inches longer than the desired lengthening.

8. Holes, one eighth of an inch in diameter, are drilled at intervals of one centimeter through the medial cortex in the line of osteotomy.

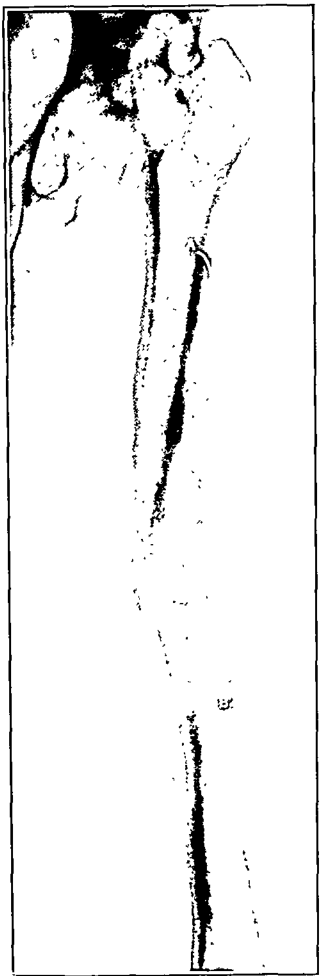

Fig. 12

Case 6. R. B., male, aged seventeen years. Roentgenogram of femur after lengthening of approximately two and three-quarters inches. Correction of adduction-flexion deformity at the site of osteotomy. The tibial bone graft *AB* has united firmly, reenforcing the zone of union.

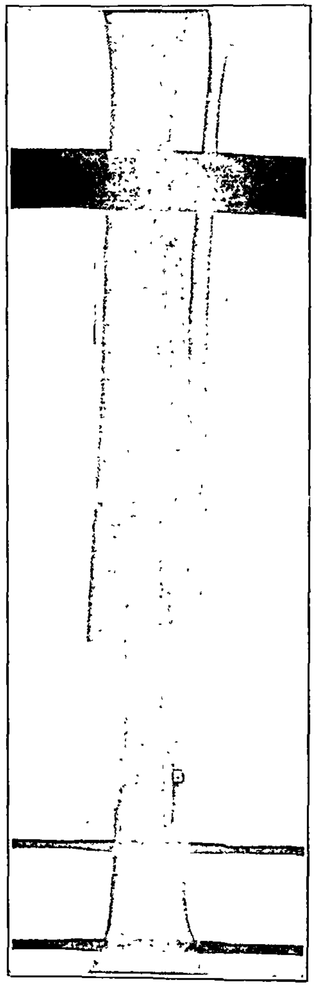

Fig. 13

Case 6. R. B. Roentgenogram after lengthening the tibia with the Moore modification of the Abbott apparatus, showing the satisfactory alignment of the fragments. The tibial bone graft *AB* is seen in position on the lateral surface, reenforcing the zone of lengthening.

9. A metal pin or wire is inserted through the femur above the condyles.

10. A tibial onlay bone graft is next added to splint the osteotomy site and to aid in union. (See Figures 10-A and 10-B.)

11. A cast is applied which includes the body and opposite leg

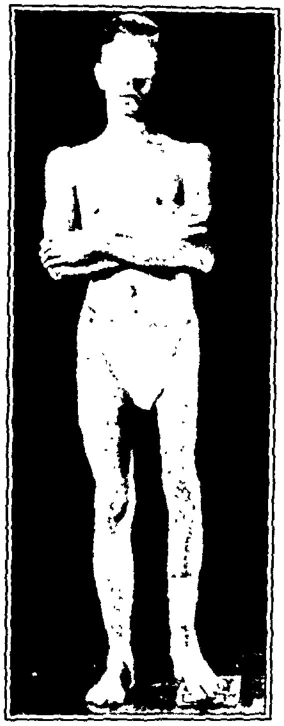

Fig. 14-A Fig. 14-B

Fig. 14-A: Case 6. R. B. At time of first admission, showing marked shortening both above and below the knee.

Fig. 14-B: Case 6. R. B. After lengthening the femur, tibia, and fibula a total of more than five inches and correction of the adduction-flexion deformity through the osteotomy, there is a functional increased length of six inches. Because of a slight flexion deformity at the knee, a raise of one centimeter is now worn on the heel of the shoe.

and which extends downward onto the upper third of the thigh of the short extremity, in which portion the proximal wire or pin is incorporated. This pin and cast immobilize the proximal fragment and reduce the variables in maintaining accurate alignment. The ring of the rigid Thomas splint is firmly attached to the cast and the lower pin to the splint by means of the turnbuckle. This affords control over the lower fragment. (See Figure 11.)

The following case illustrates the successful application of the described technique in lengthening both the tibia and the femur.

Case 6. R. B., a male, aged seventeen years, came to the University of Chicago Clinics on April 28, 1934, because of shortening of the left lower extremity amounting to fourteen and five-tenths centimeters. Tuberculosis of the left hip had been diagnosed at the age of four years. The patient had been treated by intermittent immobilization in plaster casts over a period of seven years. Since the age of eleven, there had been no flare-up in the hip. As the patient grew older it had been necessary to increase the raise on the shoe to approximately six and one-quarter inches.

Examination revealed marked atrophy and shortening of the left lower extremity (Fig. 14-A). The hip was held in a position of adduction and flexion, with only a few degrees of motion. More than two and one-half inches of the shortening was in the lower leg, the result of atrophy from long immobilization. The patient's total standing height was five feet, seven and two-tenths inches. He was acutely aware of his short stature and would have preferred amputation to reduction of his standing height by a leg-shortening operation.

On June 27, 1934, an oblique osteotomy, approximately five inches in length, was made in the left femur by the technique described. A tibial graft, one centimeter in width and twelve centimeters in length, was now tied to the proximal fragment of the osteotomized femur, so that it extended beyond the osteotomy incision. The leg was lengthened two and three-quarters inches by the application of turnbuckle traction over a period of three weeks. The wound healed *per primum* and, by correcting the adduction-flexion deformity by abducting and extending the leg at the site of the osteotomy, a total functional increase in length of more than three inches was obtained. Roentgenograms showed evidence of callus two months after the operation, and two weeks later the patient was discharged in a cast, walking with crutches. Four months and one week after operation all cast immobilization was discontinued and the patient was allowed to begin weight-bearing. There was no loss of function of the peroneal or sciatic nerve. (See Figure 12.)

Eight and one-half months after the oblique osteotomy of the femur, a lengthening operation was performed on the left tibia and fibula. A bone graft from the right tibia was attached to the proximal fragment in such a manner that it overlapped the osteotomy. The lengthening apparatus used was the Moore modification of that described by Abbott. Two and one-half inches of lengthening was obtained. (See Figure 13.) Six weeks after operation a roentgenogram showed callus and union of fragments and of the graft. A small area of necrosis of the edges of the skin in the midportion of the wound developed, but there was no suppuration.

The patient was discharged from the hospital on May 16, 1935, ten weeks after operation. There was temporary diminished sensory response over the dorsum of the foot and toe-drop. Both sensation and motor function have been recovered. A one-centimeter raise is necessary to equalize the leg length functionally. (See Figure 14-B.)

SUMMARY

In the opinion of the author the operation of choice for equalizing leg length in the majority of cases is that of shortening the longer leg by: (1) resection of a portion of the longer femur; (2) arrest of growth by fusing to the shaft one or more of the epiphyses of the longer limb.

When leg lengthening is definitely indicated the author recommends the use of a tibial onlay bone graft to bridge the zone of lengthening of either the femur or the tibia as a factor of safety in preventing delayed union, non-union, or late fracture.

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SACRARTHROGENETIC TELALGIA

III. A Study of Alternating Scoliosis

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This article is the third of a series of five*. It is based upon additional statistical analyses of the 506 records used in the first article, and it presents a detailed review of one of these records. Its scope is limited to a study of the so called "alternating sciatic scoliosis", and its purpose is to describe the mechanism of the so called "sacro-iliac slips".

In reviewing the literature we have found mention of twenty-two cases of alternating sciatic scoliosis, the first of which was described by Remak in 1891. (See Table I.) The name given to these cases refers to the presence of the following characteristic findings:

1. Telalgia in the buttocks, in the lower extremities, or in both locations.

2. Scoliosis of the type described by Steindler as "decompensated",—that is, showing a marked lateral deviation (list) of the trunk as a whole.

3. Alternation (variation in the direction) of the list that does not require voluntary effort for its maintenance after the change has occurred.

Certain additional characteristics are worthy of mention:

1. Alternation *of the list is most spectacular* when *it is produced by some type of active manipulation,* but it *may* occur spontaneously, or as the result of passive manipulation.

2. In those cases in which alternation can be reproduced at will, the change typically is sudden and painful, and is accompanied by a springlike snap that may be audible and palpable.

3. The subject cannot maintain the vertical position of the spine, but slips into one of the two lists.

4. Of the two lists, one usually is more stable than the other; that is, one list tends to be assumable only by manipulation, but it may revert spontaneously.

5. There usually is little difference in the degree of discomfort after the change has occurred.

6. The photographs of Calissano's *patient showed essentially* perfect mirror-images (that is, reversal) of the spinal curvature and rotation in the two lists, but the roentgenograms were not reproduced. No other illustrated case was symmetrical.

7. None of the observers was able to explain the mechanism of alternation, although Léri stated definitely that in his two cases the snapping sound had an osteo-articular origin.

* Of the other four articles, two have been published under the same title [18]; the remaining two are now in preparation and deal with the following phases of the subject:
IV. Diagnosis;
V. Treatment.

TABLE I

REPORTED CASES OF ALTERNATING SCIATIC SCOLIOSIS

No. of Cases	Reported by	Year
1	Remak	1891*
1	Higier	1895*
1	Mayer, O.	1895*
3	Phulpin	1895*
1	Vulpius	1896*
1	Ehret	1899*
1	Fopp	1899*
1	Lord	1913
2	Léri	1919
1	Blencke	1920*
1	Ducamp and Carrieu	1920
1	Calissano	1924
1	Stein	1924*
1	Mayer and Testu	1926
1	Dainelli	1927
3	Capener	1933
1	Fairbank	1933
Total 22 Cases		

* Cases found by Calissano.

From the fact that we could find mention of only twenty-two cases in a period of forty-five years, it appears that alternating scoliosis is a rare condition, but this is not true. Actually, only the more spectacular cases have been reported. We have found alternating scoliosis in sixty-eight, or 13.4 per cent., of our 506 cases. The change occurred in thirty-six instances as the result of passive manipulation; in twenty-two, its occurrence was spontaneous; in ten, the change was produced by active manipulation. In six of these ten instances the alternation could be reproduced at will, but mirror-images were present in only one case. This case, the detailed description of which follows, stimulated us to undertake the investigation that we are reporting in this series of articles.

CASE REPORT

N. McI., a mechanic and truck-driver, thirty-four years of age, came to us on January 30, 1929, because of "sciatica" that had affected the right lower extremity for two months.

Past History

In February 1927, the patient had suffered an injury to the right sacro-iliac joint. He was standing, bending forward about 45 degrees at the hips, with the left leg advanced, and with most of his weight supported by the right leg which was semiflexed at the knee and hip. He was lifting strongly against the handle of a large wrench, when the wrench slipped. The patient suffered immediate, lancinating pain in the right gluteal region and at once there developed a list of the trunk to the left, but he continued to work for the rest of the day (two hours). On the following morning, the patient was unable to leave his bed, because of pain in the lower back and right buttock. He returned to work on the

second day and worked steadily, although the pain and list persisted for almost two months. The list was sufficiently noticeable to cause many jests among the patient's fellow workmen, but the pain never extended to the thigh or leg.

Present Illness

Early in December 1928, the patient began to notice a gradual return of the left list. The telalgia in the right buttock also returned, but at this time it spread to the right posterior thigh and calf, with an occasional appearance in the right groin. In the latter part of December 1928, the patient was obliged to stop working, because of the increasing severity of the pain. In the latter part of January 1929, he discovered that he could alternate the list.

Condition on Admission

The patient slept poorly, and frequently was awakened by pain. He was obliged to sleep on his left side or, for short periods, on his back. The pain was greatly aggravated by prone recumbency, or by right lateral recumbency, and it was impossible for him to sleep in these positions. *To turn from supine recumbency onto the left side was difficult* and painful, but turning from the left side to the back, or even to the right side, was easy and painless. The patient could ease the pain at times by rubbing or beating against the right buttock with the heel of his hand, but he noted that pressure immediately below the posterior-superior spine of the right ilium often caused telalgia in the posterior thigh and calf. In the morning, the patient could not bend over the basin to wash his face, and he had great difficulty in walking, because of pain in the right buttock and calf "like a muscle cramping". By evening, he could walk without pain, unless he took too long a stride or made a misstep. A long, fast, or uphill walk always caused cramplike telalgia in the right calf and right groin. Coughing, sneezing, bending, lifting, prolonged sitting, and riding in automobiles all aggravated the pain; local heat and diathermy seemed to relieve it. Changes in the weather had no effect upon the degree of discomfort.

FIG. 1

Alternating scoliosis: left list. Note the position of the sacrum.

FIG. 2

Alternating scoliosis: right list. Note the position of the sacrum.

A left list (Fig. 1) was present at all times, except when the patient voluntarily shifted to the right. The patient had discovered that "something would suddenly slip", if he pressed downward upon the hips with his hands and simultaneously bent his trunk toward the right (Fig. 3). He located this "something" at the posterior-superior spine of the right ilium and stated that the "slip" often was palpable and audible as a "low-pitched pop". Just before the occurrence of the slip, the muscles of the back "seemed to set themselves in preparation" for it, and, as the slip occurred, an excruciating pain ran from the posterior-superior spine of the right ilium downward through the buttock, the posterior and lateral thigh, the calf, and the heel. There was no pain in the foot, but at times there was "an electric tingling" over the dorsal and lateral aspects of the foot and in all of the toes. After the slip had occurred the pain promptly disappeared, the patient was comfortable again, and the trunk was listed toward the right (Fig. 2).

The patient habitually used the left list, because he never shifted involuntarily from the left to the right, whereas any misstep or sudden turn would cause him to shift involuntarily from the right to the left. These involuntary slips always caused the patient's trunk to flex, as it shifted from right to left. By reversing the manoeuver that produced the right list, the patient could produce the left list without flexing the trunk. As the slip occurred, an excruciating pain ran from the right heel upward through the calf, occasionally into the posterior thigh, more rarely into the groin, but never into the buttock.

The patient was intelligent, cooperative, mechanically-minded, and an accurate observer. There were no symptoms of neurosis or of coincidental strain in other joints, and no complications caused by compensation, insurance, or legal tangles.

Physical Examination

The general examination showed that the patient was a healthy, well-developed, and well-nourished individual of the "normal" anatomical type. The local examination, with the patient in the erect position, resolved itself into the examination of three different individuals: the first, listed to the left (Fig. 1); the second, listed to the right (Fig. 2); and the third, in the act of changing the direction of the list (Fig. 3).

Left List: There was obvious spasm of both sacrospinalis muscles, which was more marked on the left. The left shoulder was carried lower than the right. The shoulder girdle and upper chest were rotated toward the left about the long axis of the trunk. The pelvis, as a whole, was rotated toward the right about the long axis of the trunk. The spine showed a lateral scoliosis which was convex on the left in the dorsal region and convex on the right in the lumbar region. The pelvis, as a whole, was shifted laterally toward the right for a distance of one and one-half inches. The right gluteal crease was one inch lower than the left. The normal lumbar lordosis was increased. The left posterior-superior iliac spine was lower than the right, and a line connecting the two deviated 7 degrees from the plane of the horizon. The left lower extremity was held in a position of 10 degrees of internal rotation. Palpation revealed tenderness of both posterior sacro-iliac ligaments on the right side.

FIG. 3

Alternating scoliosis: shifting. The change from the left to the right list has taken place, but the secondary dorsal curve and rotation have not made their appearance.

Tenderness was most acute just below the right posterior-superior iliac spine. Forward bending to 30 degrees was painless, but at this point the patient began to flex the right knee and to complain of pain in the right gluteal region. Continued forward bending caused the pain to radiate downward, first into the posterior and lateral thigh, and then into the calf. The patient would not bend beyond 45 degrees. Backward bending was normally performed to 35 degrees without pain. The angle of inclination of the right ilium was increased and measured 20 degrees*.

Right List: The patient showed a mirror-image (*i.e.*, a reversal) of the following items that we mentioned in our description of the left list: the spasm of the sacrospinalis muscles, the level of the shoulders, the rotation of the shoulder girdle and of the pelvis as a whole, the lateral spinal scoliosis, the lateral shift of the pelvis, and the level of the gluteal creases. The normal lumbar lordosis was decreased. The right posterior-superior iliac spine was lower than the left, but a line connecting the two deviated only 2 degrees from the plane of the horizon. The internal rotation of the left lower extremity disappeared. Palpation revealed tenderness of both posterior sacro-ischial ligaments on the right side, but the tenderness of the sacro-iliac ligaments disappeared. Tenderness was most acute over the free medial edge of the sacrotuberous ligament, just above the ischial tuberosity. Forward bending to 45 degrees was painless; at this point the patient complained of cramplike pain in the right calf, but he did not attempt to flex the right knee. Continued forward bending caused the pain to radiate upward into the posterior thigh, but not into the buttock, and the patient would not bend beyond 55 degrees. Backward bending, to an angle of not more than 10 degrees, caused a sudden pain in the right anterior thigh,—a type of telalgia that the patient had not experienced previously. This was so severe that the patient suddenly and involuntarily flexed his spine, shifted back into the left list, and thereafter was unwilling to repeat the manoeuver. The angle of inclination of the right ilium was decreased and measured 5 degrees.

Shifting from Left to Right: The patient placed his hands upon his hips and slowly forced the trunk toward the vertical position (right), at the same time forcing the pelvis toward the left. The rotation of the shoulder girdle and of the pelvis about the long axis of the trunk disappeared. As the upper spine reached the midline, the entire musculature of the back became boardlike in its rigidity; the right sacro-ischial ligaments became exquisitely tender; and the patient complained of pain in the right buttock and posterolateral thigh. As suddenly as when a spring is released, and just as the upper spine passed the midline, the curve of the lumbar spine was reversed, and the lumbar lordosis was decreased. Simultaneously, a deep, hollow pop was produced, the maximum intensity of which we located by palpation and by auscultation at the right posterior-superior iliac spine, and the patient complained momentarily of an exquisite pain that radiated from the right buttock and thigh to the calf and heel. The rotations of the shoulder girdle and of the pelvis, the lateral shift of the pelvis, and the inequality in the tension of the sacrospinalis muscles, all appeared in their new forms as the pressure of the hands was released and as the trunk settled down into the right list.

Shifting from Right to Left: When voluntarily produced, this shift was an exact reversal of the shift from left to right. Just as the upper spine reached the midline, the posterior sacro-iliac ligaments became exquisitely tender, and the patient complained of pain in the right calf. Just as the popping sound occurred, the patient complained momentarily of an exquisite pain that radiated from the right calf upward into the posterior thigh and occasionally into the right groin.

Sitting: The patient could bend the trunk to the right or to the left without any slip or pain, but the left-dorsal-right-lumbar scoliosis remained. He could bend forward 60 degrees without pain until his chest touched his thighs. The left knee could be extended actively to 180 degrees without pain, but even the effort involved in starting to extend the right leg caused pain in the right buttock. This pain radiated down the right posterior thigh and calf, if extension was continued, and limited extension to 135 degrees.

* This was the first case in which we measured the angle of inclination, and there is no record of the inclination of the left ilium.

Prone Recumbency: In this position, the muscle spasm, the list, and the spinal curvature disappeared. Any motion caused spasm of the muscles to reappear. If the patient rose to the knee-chest or knee-hand position, the left-dorsal-right-lumbar scoliosis reappeared. Tenderness of the posterior sacro-iliac ligaments remained. In left prone-knee flexion [17], the heel came to within six inches of the sacrococcygeal junction before the buttock began to rise (Ely's sign), but in right prone-knee flexion, the buttock began to rise at nine inches, and the patient complained of pain in the right gluteal region.

Right Lateral Recumbency: The patient could not maintain this position long enough for examination, because it produced telalgia in the right buttock, posterior thigh, and calf.

Left Lateral Recumbency: Compression of the iliac crests did not produce telalgia. Gaenslen's sign (acute flexion of the left hip to fix the pelvis, and passive extension of the right hip) produced pain in the right buttock while the right hip still remained in a position of 10 degrees of flexion.

Supine Recumbency: In combined hip-and-knee flexion, the patient could bring both thighs against the chest without pain. Passive straight-leg raising was stopped on the left at 85 degrees by tension of the hamstring tendons, but it was stopped on the right at 22 degrees by pain in the right buttock, and any attempt to carry the leg higher caused telalgia in the posterior thigh and calf. Both lower extremities were equal in length and in circumference. The cremasteric reflex, the patellar reflex, and the Achilles-tendon reflex were all slightly diminished on the right.

Roentgenographic Examination

In the supine position, the spine was straight, there were no arthritic changes, and no noteworthy congenital anomalies. Teleoroentgenograms of the spine in the two lists (Fig. 4) showed the "structural" [2] type of scoliosis that we have described in the physical examination. Similar roentgenograms of the pelvis (Fig. 5) showed lateral bending of the sacrum toward the right in the left list, and toward the left in the right list.

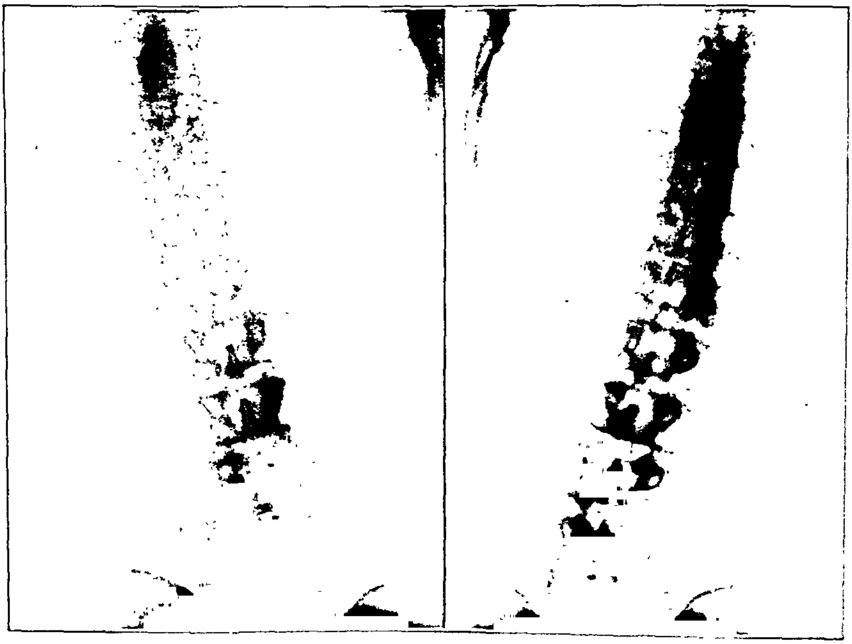

FIG. 4

Alternating scoliosis. Teleoroentgenograms of the spine, taken with the subject in the standing position and viewed from behind.

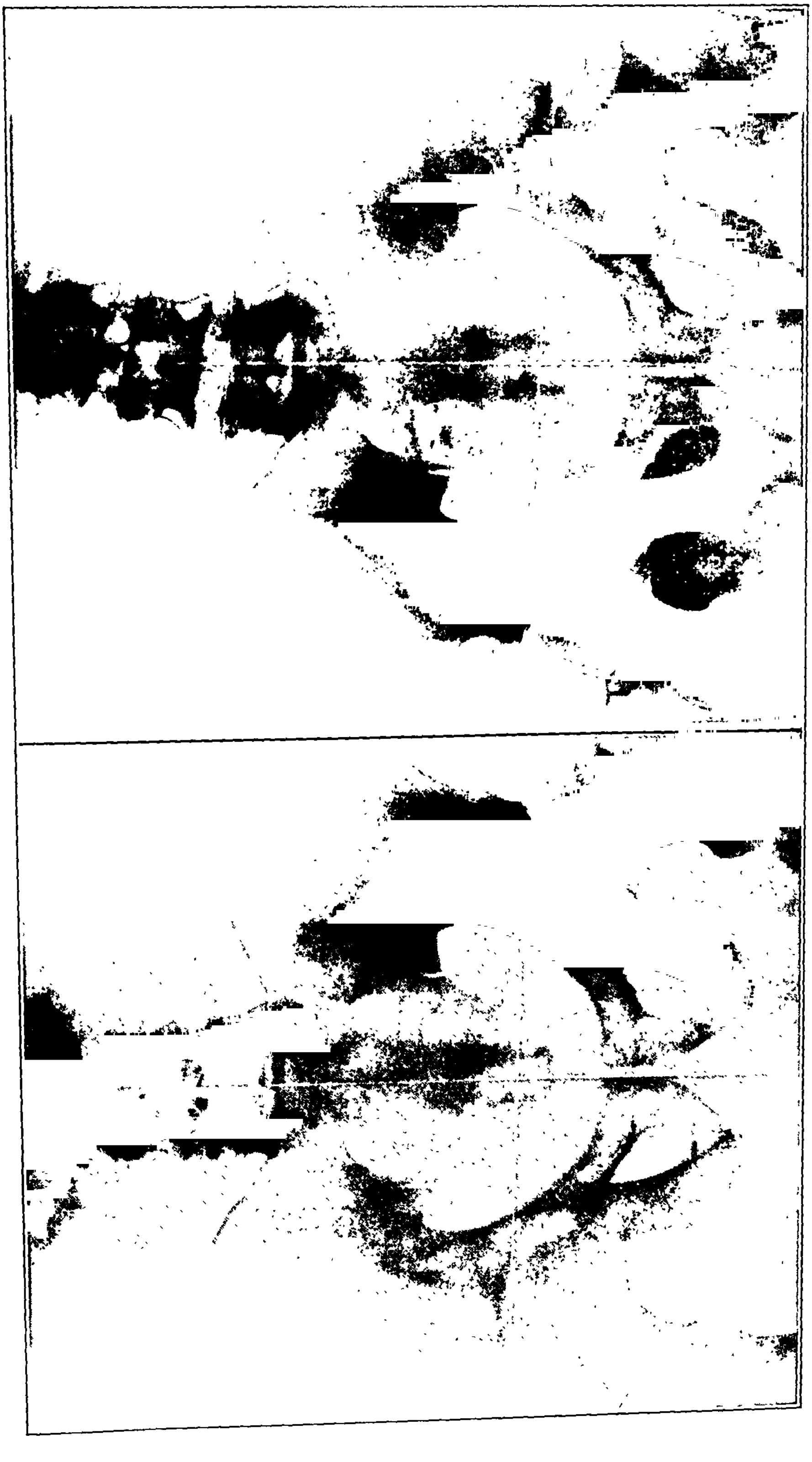

Fig. 5

Alternating scoliosis. Teleoroentgenograms of the pelvis, taken with the subject in the standing position and viewed from behind. (The apparent inequality in the length of the lower extremities is due to the error of the photographer who used the line drawn through the middle of the sacrum as a vertical in placing the films for reproduction.)

In this case, the patient's unequivocal localization of the "something" that slipped, the adventitious sounds of osteo-arthritic origin, the type of the telalgia, the ligamentous tenderness, and the usual tests by which we were accustomed to diagnose sacro-iliac dysfunction, all directed us to the right sacro-iliac joint as the cause of the alternating scoliosis. Still, one might consider this joint to have been more sinned against than sinning, if it were not for the following facts:

1. The reactions of the presacral vertebral column were the usual ones that are found when the internal balance is disturbed (as by an hemivertebra) or when the external support is deranged (as by paralysis or contracture of muscles). No such bony or muscular abnormality could be demonstrated.

2. Lateral bending in the standing position caused alternation of the scoliosis; lateral bending in the sitting position did not. Since the actions of the intrinsic spinal muscles are not altered in these two positions, the pelvic musculature must have been of paramount importance in the production of alternation.

3. Pathological mobility of the sacrum was demonstrated in the roentgenograms (Fig. 5). In the left list, in which the inclination of the right ilium was sharply increased, the right side of the sacrum did not follow the ilium upward and forward, as it should have done normally*. The roentgenogram shows very clearly that the right side of the sacrum has moved downward (and backward), so that a line drawn through the center of the sacrum falls to the left of the symphysis pubis. Thus, the foundation of the spine is deviated (and rotated) toward the right. Similarly, in the right list, in which the inclination of the right ilium was sharply decreased, the right side of the sacrum moved upward (and forward), again reversing the direction of normal movement.

4. The left list was more stable than the right list, just as the sacrum is more stable in flexion than in extension, because the sacrum had slipped downward and backward into the iliac mortise. Any unguarded movement tended to unlock the sacrum in the unstable right list (upward and forward slip), and gravity promptly returned it to the stable position.

5. The stable left list persisted in the standing, sitting, knee-hand and knee-chest positions. Therefore, the fixed position of the sacrum in the stable slip did not depend upon the action of the pelvic musculature which was so important in the production and maintenance of the unstable slip.

* In the second article of this series we showed that the sacrum normally exhibits two types of motion:

1. Flexion and extension about the transverse axis of the sacrum. In flexion, the sacrum glides downward and backward upon the ilia. Since the iliac mortise is constricted inferiorly and posteriorly, the sacrum is more firmly wedged between the ilia and is more stable in flexion than in extension.

2. Lateral bending and rotation. These two motions never are encountered separately. They are caused by antagonistic movements of the ilia about the transverse axis of the symphysis pubis. When an ilium decreases its angle of inclination, the contiguous sacral surface moves downward and backward. When an ilium increases its angle of inclination, the contiguous sacral surface moves upward and forward.

6. The right gluteal fold was lowered (gluteal relaxation) in the stable left list and was elevated (gluteal contraction) in the unstable right list. The contraction of the gluteus maximus muscle extends the sacrum (upward and forward motion) and decreases the iliac inclination, thus tending to maintain both elements of the unstable slip.

7. The scoliosis disappeared in recumbency and reappeared when recumbency ceased. Therefore, the cause of the scoliosis did not lie within the presacral vertebral column, but in the effort of the spinal muscles to balance the vertebral column upon a foundation that had shifted from its normal position*.

The two sacro-iliac slips shown in this case were a sufficient cause and the only presenting cause of the alternating sciatic scoliosis. They represent derangements in the second type of normal sacro-iliac motion (lateral bending and rotation of the sacrum) in which the sacrum fails to follow the motion of an ilium, but slips past it and locks both the sacrum and that ilium in an abnormal position. For convenience, and because this type of sacral motion normally is secondary to iliac motion, we shall classify these slips hereafter as "iliac slips" and shall designate them as "increased-angle slips" or "decreased-angle slips".

There is another group of slips that we shall classify hereafter as "sacral slips" and shall designate as "flexion slips" or "extension slips". In sacral slips, one side of the sacrum travels with the contiguous ilium in the normal manner, but the joint becomes locked at one of the two extremes of normal motion. The mechanism of this slip becomes clearer if we remember that, as the inclination of an ilium increases, the sacrum is carried upward and forward *on the long arc of iliac motion.* When the normal limit of passive sacral motion is reached, any one of three events may transpire, if the angle of iliac inclination continues to increase, and if the symphysis pubis is not ruptured:

1. The sacrum may flex (move backward and downward on the short arc of normal sacral motion), thus relaxing the posterior sacro-iliac ligaments and allowing a further increase in the inclination of the advancing ilium. This is the normal action that we described in the second article of this series.

2. When a point is reached beyond which the sacrum cannot follow the advancing ilium, that side of the sacrum may slip backward and downward as the iliac angle increases. This is the "increased-angle slip" that we have just described.

3. If the sacrum is flexed completely and is so tightly wedged into the iliac mortise that an iliac type of slip cannot occur, the interlocked articular surfaces of the advancing ilium and of the sacrum act as a pair of enmeshed gears. The large iliac gear forces the small sacral gear upward and forward into extension at the expense of the posterior sacro-iliac

* The correlation of ligamentous tenderness with the distribution of telalgia, of which this case offers a striking example, was covered thoroughly in the first article of this series.

ligaments. Sacral extension loosens the iliac mortise, thus allowing the teeth of the imperfect gear to jump a cog and become jammed. This is the "extension slip" in which the sacrum and one ilium are locked in a position of sacral extension and increased iliac inclination. The "flexion slip" locks a sacro-iliac joint in a position of sacral flexion and decreased iliac inclination.

Sacro-iliac slips were present in 326 (64.0 per cent.) of our 506 cases. Of these 326 cases, 166 (51.0 per cent.) showed unilateral or bilateral sacral slips; 85 (26.0 per cent.) showed a sacral slip in one joint and an iliac slip in the other joint, and 75 (23.0 per cent.) showed unilateral or bilateral iliac slips. Three findings were common to every one of these 326 cases:

1. A history of sacrarthrogenetic telalgia;
2. Tenderness of the posterior sacro-iliac or sacro-ischial ligaments;
3. Lateral spinal scoliosis.

SUMMARY AND CONCLUSIONS

1. The authors have found twenty-two cases of alternating scoliosis mentioned in the literature. The apparent rarity of this condition is due to the fact that only the more spectacular cases have been reported.

2. The authors have found sixty-eight cases of alternating scoliosis in their records of 506 examinations for low-back disability. Six cases showed the spectacular type of active alternation.

3. The pain of alternating scoliosis is the typical sacrarthrogenetic telalgia that is caused by pathological tension in the extra-articular ligaments of the upper sacral joints.

4. The scoliosis is caused by one or more fixed pathological positions of one or more of the upper sacral joints.

5. Alternation is due to a change in the fixed pathological position of one or more of the upper sacral joints.

6. Either sacro-iliac joint may become fixed in one of four pathological positions (sacro-iliac slips) which the authors have classified as follows:

a. Sacral slips:
   (1) Flexion slips;
   (2) Extension slips.

b. Iliac slips:
   (1) Increased-angle slips;
   (2) Decreased-angle slips.

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STUDY OF FUSION OF THE SPINE WITH PARTICULAR REFERENCE TO ARTICULAR FACETS *

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It is twenty-four years since Hibbs performed his first spinal fusion on January 8, 1911. The operative procedure at that time consisted of interlocking the denuded spinous processes and was a marked advance over the operations of Chipault and Hadra, who used wire sutures, and of Lange, who placed a wire or celluloid strips along the spinous processes. In the report of further operations by Hibbs in 1912 it is noted that, in addition to interlocking the spinous processes, he raised up sections of bone from the laminae. It was not until 1918 that the destruction of the articular facets was instituted and the operation was developed to its present refinement. This operative procedure of Hibbs gives to orthopaedic surgery one of the most exacting techniques based on sound physiological and mechanical principles, and marks an epoch in this specialty.

Although no mention is made as to the reasons for each one of these additions, it can be presumed that they were for the specific purpose of hastening union and giving firmer fixation and maximum efficiency.

Six months after Hibbs's report Albee described his well-known operation in which the spinous processes are fixed by a tibial graft. Albee claimed that the preservation of the spinous processes and the posterior spinal ligaments with their leverage action was very important. He also stressed the importance of keeping one-half of the spinous process intact in order to allow better vascularization of the bone grafts. It is interesting that de Quervain in 1911 independently employed a bone graft to immobilize the lower cervical spine for dislocations of the fifth and sixth cervical vertebrae. Numerous modifications of the methods of Hibbs and Albee have been proposed since the original operations.

This investigation is not concerned with the merits of the various types of operations, but with a study of the changes in the articular facets following the fusion of the spinous process alone or in conjunction with the laminae. This is of importance from an academic as well as from a practical standpoint. It is a study of the changes in the intervertebral articulations following extra-articular fusion. Little information is obtainable relative to the changes that take place in these articulations after a spinal fusion in which they are not destroyed.

Albee, in December 1911, performed some interesting experiments in which he placed a bone graft in the spinous process of a dog. He obtained a successful fusion, but made no mention of the changes in the

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articular facets. He also carried out several experiments in which the spinous processes were interlocked without a bone graft. There was no immobilization of the animals after the operation and he reported that no union took place even between the spinous processes.

De Quervain and Hoessly, in 1916, experimentally transplanted bone into the spines of dogs, but they made no mention of the changes in the articulations.

In the experiments that form the basis of this report the spinous processes were made to interlock with each other. In some of the operations, in addition to the fusion of the processes, bone was thrown up from each lamina and made to contact with bone from the laminae of the adjoining vertebrae above and below. In other experiments, in addition to the interlocking of the spinous processes and the laminae, the articular facets were destroyed on one side only. A study was then made of the spine, particular attention being directed to the articular facets which had been destroyed. Some surgeons have claimed that it is not necessary to destroy the facets and that sufficient fixation will be obtained by the fusion of the spinous processes. It has also been suggested that secondary changes will take place in the facets, with their subsequent fusion.

If spontaneous fusion should take place in the facets, the operator would be spared a considerable amount of painstaking work, and the operation would be simplified and shortened.

It is hoped that the following experiments will throw some light on these interesting questions. The experiments will be considered under the following headings:

(1) Simple fusion of the spinous processes;
(2) Fusion of the spinous processes and union of the laminae;
(3) Fusion of the spinous processes, laminae, and the facets on one side.

SIMPLE FUSION OF THE SPINOUS PROCESSES

EXPERIMENT 1. Dog 3, six months old. Duration of experiment, thirteen days.

Operation: After having been exposed, the lumbar spinous processes were denuded by stripping off the surrounding tissues subperiosteally. The spinous processes were then split into several pieces and interlocked with fragments of bone from the spinous processes above and below.

Gross examination: A definite sense of firmness was found in the area of the spine which had been operated upon. There appeared to be some proliferation between the interlocked fragments of the spinous processes. The parts of the laminae near the spinous processes were covered by new osteoidlike tissue. The articular facets were unchanged, and free motion could be obtained on manipulation. On further exposure, the articular cartilages were found to be normal.

Roentgenographic examination: The roentgenogram showed no changes in the facets. There was interlocking of the fragments, but no osseous proliferation could be seen at this early stage.

EXPERIMENT 2. Dog 1, almost full-grown. Duration of experiment, twenty days.

Operation: After having been exposed and denuded by stripping off the muscles subperiosteally, the lumbar spinous processes were interlocked with each other. The animal was immobilized in plaster for two weeks.

Gross examination: In spite of the relatively short period of twenty days, there was considerable fixation in the area of operation. There was definite proliferation of new osteoid tissue between the processes, with a tendency to extend out over the laminae. The articular facets appeared in a normal position, and the articular cartilage of the facets appeared to be of normal color, thickness, and structure.

Roentgenographic examination: Roentgenograms showed no changes in the articular facets. The spinous processes appeared to be in apposition.

EXPERIMENT 3. Dog 2, young, full-grown. Duration of experiment, 170 days.

Operation: The spinous processes were interlocked with each other, but the laminae and articulations were not disturbed.

Gross examination: There was marked rigidity of the spine. Bony bridging between the spinous processes was noted but very little bone was thrown out on the laminae; only the parts near the spine were bridged across. Some of the articular facets were covered by new bone and appeared to be fused. However, on removal of this thin layer of new bone, the articular cartilages were found slightly changed, but the motion between the surfaces was less free than normal. In places there was some destruction of cartilage and what appeared to be beginning bridging across. The majority of the articulations showed restricted motion and thinning of the articular cartilage, but no union.

Roentgenographic examination: All of the articular facets could be seen very clearly in an oblique view in the plane of the facets. Some appeared more indistinct than others. There was an osseous bridging between the spinous processes. In some places there were rarefied areas which might be cleavage planes of osteoid tissue extending across the spinous processes.

Microscopic examination: There was definite articular cartilage on both sides of the partially fused facets. The structure of the cartilage was somewhat thinner than normal, and the nuclei were not quite as numerous and as regular as in normal cartilage. No osseous union was found.

Where the spinous processes only were interlocked, there was considerable fixation of the spine in the area of operation, even as early as twenty days. At the end of 170 days there was firm union of the spinous processes, but there were very few secondary changes in the articular facets. Some showed a bridging over on the surface, and it took considerable force to obtain any motion between the facets.

FUSION OF THE SPINOUS PROCESSES AND UNION OF THE LAMINAE

EXPERIMENT 4. Dog 4, three months old. Duration of experiment, thirty-four days.

Operation: The spinous processes were exposed, and the muscles were stripped off subperiosteally to either side. No attempt was made to expose the articular facets. The spinous processes were split and made to interlock with those above and below. Sections of bone were thrown up from the laminae, but special effort was made not to approach the articular facets. The animal was immobilized in plaster for twenty-eight days.

Gross examination: There was considerable rigidity between the spinous processes with evidence of bone proliferation. The articular facets could be distinguished and there was considerable motion between the two articular cartilages.

Roentgenographic examination: The articular facets showed a normal outline with no evidence of change in the articular cartilage.

EXPERIMENT 5. Dog 5, three months old. Duration of experiment, 205 days.

Operation: The spinous processes were exposed and the muscles were stripped off subperiosteally. The spinous processes were split in half and then interlocked. Small sections of bone were thrown up from each lamina to the laminae above and below and over the articular facets. The articular facets were not destroyed.

Gross examination: There was firm fusion of the spine and of the laminae in the area

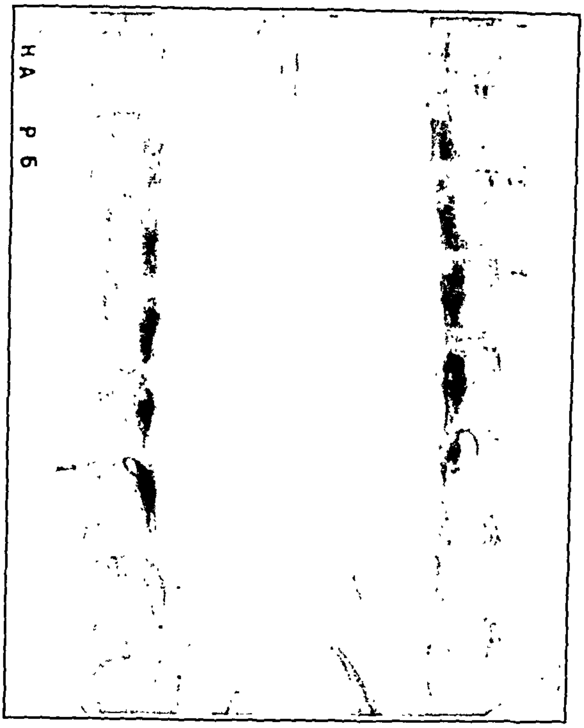

FIG. 1

Experiment 5. Dog 5. Duration of experiment, 205 days. The spinous processes and the laminae were fused by operation. The intervertebral articulations were not disturbed. All of the articular cartilages were present, but distorted. Some of the joints showed partial ankylosis. The arrows point to the joints which showed the most changes.

of operation. No evidence of motion could be ascertained even in the articular facets. The articular facets were not visible, as a layer of bone had formed over them. Furthermore, there was marked distortion in the plane of the facets. It appeared as though the new bone, which was formed about the laminae, had displaced the facets away from the spinous processes and had rotated the plane of the joints. After the removal of the superficial layer of bone, some of the articular cartilage of the facets could be found in apposition to a similar layer of cartilage. It was possible to peel one layer off the other, but the approximation was so close that no movement took place between them. One of the articular facets was entirely obliterated, while several others showed partial destruction and partial fusion.

Roentgenographic examination: The articular facets on both sides could be distinguished, but they showed marked changes in size, shape, and outline. Several could scarcely be discerned and appeared to be entirely fused, which agreed with the gross findings (See Figure 1).

Microscopic examination: The one facet which appeared to be fused, both in the gross and in the roentgenographic examinations, showed a small portion of articular cartilage with fibrous tissue on the surface. The cartilage was undergoing degeneration, being poorly stained and irregular in structure. There was some evidence of osseous union. A microscopic section from one of the joints that appeared to be fused, in which two closely applied articular cartilages were found, showed two layers of cartilage, one of which was thinner and more irregular than the other.

In this experiment in which the facets were not destroyed, but were merely covered by bone thrown over them from the laminae, there were definite secondary changes in the articular facets. There was good fixation of the overlying tissues and it was probably because of the loss of motion that the secondary changes took place in the articular facets. Several of the facets appeared arthrodesed and only part of the cartilage was found. Other facets showed degenerative changes in the cartilage. These changes were not as marked as in the next series where the facets were destroyed on one side. There was no evidence of motion and none could be produced by manipulation.

FUSION OF THE SPINOUS PROCESSES, LAMINAE, AND THE FACETS ON ONE SIDE

EXPERIMENT 6. Dog 7, young pup. Duration of experiment, twenty-seven days. *Operation:* An incision was made over the spinous processes. The muscles were

reflected subperiosteally well out to the articular facets. On the left, three articular facets were destroyed and two others were covered by bone from the laminae. Nothing was done to the facets on the right. The animal was immobilized in plaster for twenty-seven days.

Gross examination: There was definite increased rigidity of the spine in the area of operation. Definite osteoid and osseous tissue could be seen between the spinous processes. The articular facets on the left showed very little, if any, evidence of motion. The cartilage was entirely absent in some, while in others it was only partially present. On the right, where the articular cartilages were not destroyed, there was a little motion in all the articular facets. There was no appreciable change in the articular cartilages, although they appeared slightly thinner than normal.

Roentgenographic examination: The spinous processes were well interlocked. There was no definite evidence of osseous union. The articular facets on the right, which were not destroyed, appeared normal. Those on the left, which were curetted, had irregular outlines. They showed definite signs of destruction, some more than others, depending on the amount of operative interference.

Microscopic examination: There was a marked amount of callus between the spinous processes. The articulations which were destroyed showed some small remnants of articular cartilage of irregular structure. The cancellous bone was poorly stained and there was very little evidence of callus. The articular cartilages that were not destroyed were of normal appearance and structure.

Experiment 7. Dog 6, full-grown. Duration of experiment, 160 days.

Operation: The spinous processes were exposed, and the muscles and fascia were stripped off subperiosteally well out to the articular facets. On the right side the articular facets were destroyed, while on the left they were left intact. The animal was immobilized in plaster for six weeks.

Gross examination: There was firm union between the spinous processes. On dissection, several small cleavage planes were found extending transversely across the fused area. These lines of cleavage appeared to bear some relation to the intervertebral articulations on each side. The articular facets on the right, which were destroyed, were completely fused. In several, there were some small particles of cartilage which may have been remnants of articular cartilage or callus which was not ossified. There were no signs of any joint spaces or even two leaves of cartilage.

On the left side, where the articular facets were not destroyed, there was absolutely no sign of any motion. When the region of the articulations was exposed, they appeared completely ankylosed. After the superficial layer of bone had been removed, remnants of the articular cartilage could be made out. There were no joint spaces and in only one joint could two layers of cartilage be found. These two layers of cartilage were very closely and firmly approximated.

Roentgenographic examination: The facets on the right side were destroyed and appeared to be completely arthrodesed. On the left

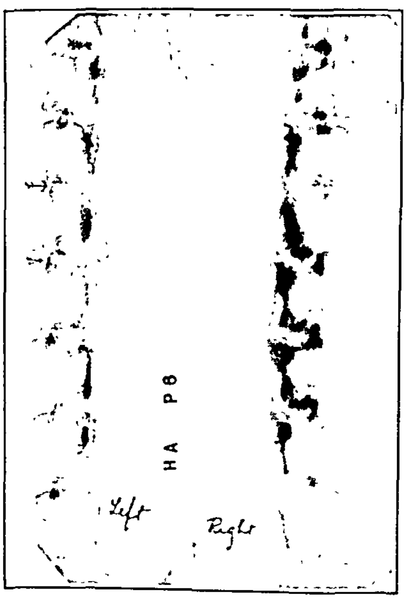

Fig. 2

Experiment 7. Dog 6. Duration of experiment, 160 days. The spinous processes, laminae, and intervertebral articulations on the right were fused at operation. The arrows indicate two of the intervertebral articulations on the left which underwent fusion without operative destruction. The remnants of the articulations on the left showed varying degrees of injury.

side, where the facets were not destroyed, there were irregular rarefied areas representing what remained of the articulations. One joint appeared to be completely destroyed. (See Figure 2.)

Microscopic examination: Sections were made of two of the joints on the non-operated side. One, which appeared fused on macroscopic study, showed a small remnant of articular cartilage which was poorly stained and appeared to be undergoing degeneration. The greater part of the tissue consisted of normal appearing trabeculated bone within which were a few strands of cartilage tissue such as would be found in an arthrodesed joint. The other section from the area where there was gross cartilage present showed fairly normal articular cartilage beneath which were normal trabeculae and marrow.

In those cases in which the facets on one side were destroyed there was more rigidity of the spine than in the cases in which the facets were not destroyed. The articular facets on the non-operative side showed very marked secondary changes. There were no signs of joint spaces and some of the joints were practically fused, only small remnants of cartilage being present. One set of the facets was in such close apposition that the two articular cartilages could be separated only by force.

SUMMARY

In the experiments in which the spinous processes alone were fused, there were practically no changes in the articular facets.

When, in addition to the fusion of the spinous processes, sections of bone were thrown up from the laminae and over the articular facets, secondary changes took place in the facets that had not been destroyed. In one experiment of 205 days' duration, several of the articulations were partially arthrodesed.

If, in conjunction with the fusion of the spinous processes, the articular facets were destroyed on one side, marked changes took place in the articular facets of the opposite side. After 160 days very slight remnants of articular cartilage were found in some of the undestroyed articulations. No signs of joint spaces were found, although some joints showed the persistence of two articular cartilages.

There was marked distortion of the plane of the facets with heaping up of bone about them on the side which had not been operated upon, as well as on the side upon which an operation had been performed.

The changes described took place in normal spines. One would expect greater changes if a diseased condition or abnormal pressure as in scoliosis were present.

CONCLUSIONS

1. Fusion of the spinous processes alone produces no secondary changes in the intervertebral articulations.

2. Fusion of the spinous processes and laminae with bone thrown up over the intervertebral articulations causes loss of motion and partial destruction of some of the intervertebral joints.

3. After fusion of the spinous processes and laminae and destruction of the intervertebral articulations on one side, marked changes take place

in the articulations on the opposite side, some of the articulations being almost completely ankylosed.

4. It is advisable to destroy the intervertebral articulations in the Hibbs spinal-fusion operation in order to obtain the most rapid and efficient fixation.

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THE KNEE-FLEXION TEST FOR PATHOLOGY IN THE LUMBOSACRAL AND SACRO-ILIAC JOINTS

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Pain in the lower part of the back may be due to involvement of the gynecological, genito-urinary, gastro-intestinal, retroperitoneal, or skeletal tracts. In addition to this, the somatic manifestations of the neurotic and the wilful prevarications of the malingerer may focus attention on this area. Tests which help allocate the pathology to the particular system involved are therefore valuable. A number of such tests have already been described. The following test is offered because it is simple and because, by its remote control, it avoids the confusion that attends direct manipulations of structures near the affected area.

In this test the patient lies relaxed in a prone position on a rigid examining table, and the examiner flexes the knee by raising the foot up from the table. If the test is positive, the patient experiences pain in the sacro-iliac or lumbosacral region, and at times along the nerves that run in front of these joints. The radiating pain follows the course either of the sciatic nerve, along the back of the limb to the calf, or the external cutaneous nerve of the thigh, on the outer side of the thigh to the knee. If the patient has no skeletal pathology in the lower part of the back, he will experience no pain, or only a feeling of tension in the front of the thigh.

The possibilities for error in technique are few. The only necessary precautions are: (1) the table should be flat and non-yielding; (2) the patient should lie prone and relaxed, with the limbs side by side; and (3) the leg should be passively raised directly up to flex at the knee. It is occasionally desirable to rest a hand lightly on the back to keep the patient from buckling at the hips. (See Figure 1.)

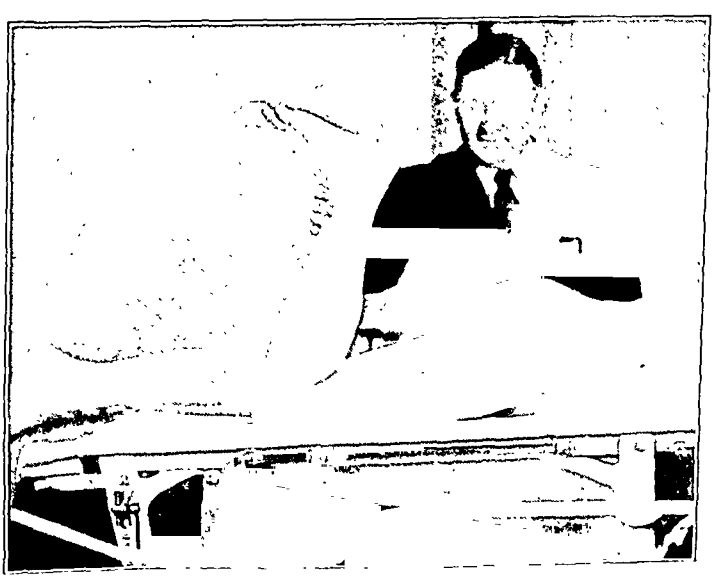

FIG. 1

The knee-flexion test for low-back pathology.

The principle of this test is simple. When the knee joint is flexed, the patella and the rectus femoris

Fig. 2

Diagram to indicate the force exerted on the ilium when the knee is flexed. The patella *P* is pulled down and, through the rectus femoris muscle, exerts a displacing force along the line *SP* on the anterior-inferior iliac spine *S*. Since the ilium rests on the head of the femur and rotates around *C*, the displacement will take place along the arc *A*.

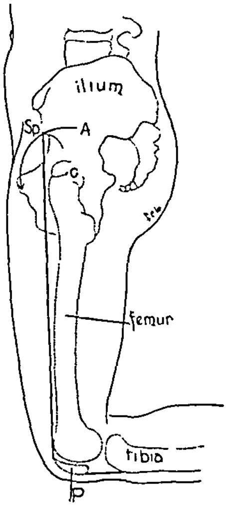

Fig. 2

muscle which is attached to it are pulled distally. The long head of the rectus femoris is attached to the anterior-inferior iliac spine about two inches in front of the center of rotation of the innominate bone on the femur. Consequently, the flexion of the knee tends to rotate the ilium forward and downward. (See Figure 2.) This torsional force manifests itself as a strain on the nearest sacro-iliac joint. When this joint is intact, the sacrum is carried with the ilium, so that strain is applied either to the lumbosacral or to the opposite sacro-iliac joint. The strain on a diseased joint causes pain in the joint itself, but the displacement produced, if enough to cause pressure on the adjacent nerve trunks, is often recognized by pain referred to the skin-sensory areas of the affected nerve.

In the decade that has elapsed since the author first presented this observation the test has been used in many hundreds of cases. There are some definite conclusions to be drawn as to its value. A positive test may be accepted as an indication that disease is present in the lower part of the back, and, when the response is felt in a specific joint, it is safe to assume that that joint is the affected one. On the other hand, one cannot deduce the type of the involvement,—that is, one cannot differentiate trauma from arthritic affection. A negative reaction does not rule out skeletal pathology. Occasionally one obtains a positive reaction with this manoeuver when the Goldthwait or so called Lasègue test is negative. Generally speaking, however, the rectus femoris pull is not as frequently positive as is the hamstring test. The knee-flexion test has one particular advantage, of especial value in treating nervous patients,—namely, the normal tension discomfort produced by the manoeuver is felt only on the front of the thigh, so that it can easily be distinguished from the "positive" reaction which is felt on the posterior aspect. Finally, the simplicity of the procedure recommends it as an additional diagnostic measure.

FRACTURES OF THE PROXIMAL PHALANGES

Alignment and Immobilization

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It is an undisputed fact that fractures involving the proximal phalanges of the hand *must* be immobilized in *flexion*. This is due to the constant deformity present,—flexion of the proximal fragment and extension of the distal fragment. (See Figures 1 and 4.)

To align these fragments and to hold them in the corrected position, it has been the custom to bend the phalanx over an anterior pliable metal splint and to fix it in that position. This correction is accomplished and maintained by the upward pressure of the convex portion of the splint against the anterior angulation of the fracture and the counter or downward pressure on the ends of the phalanx. When marked flexion is necessary, this upward pressure may be strong enough to cause local necrosis of the skin and the conversion of a simple fracture into a compound, infected one. This happened in one of our cases.

The author's attention was focused on this problem when he was called to see a patient who had sustained fractures of the proximal phalanges of the third, fourth, and fifth fingers (Fig. 1). Three separate

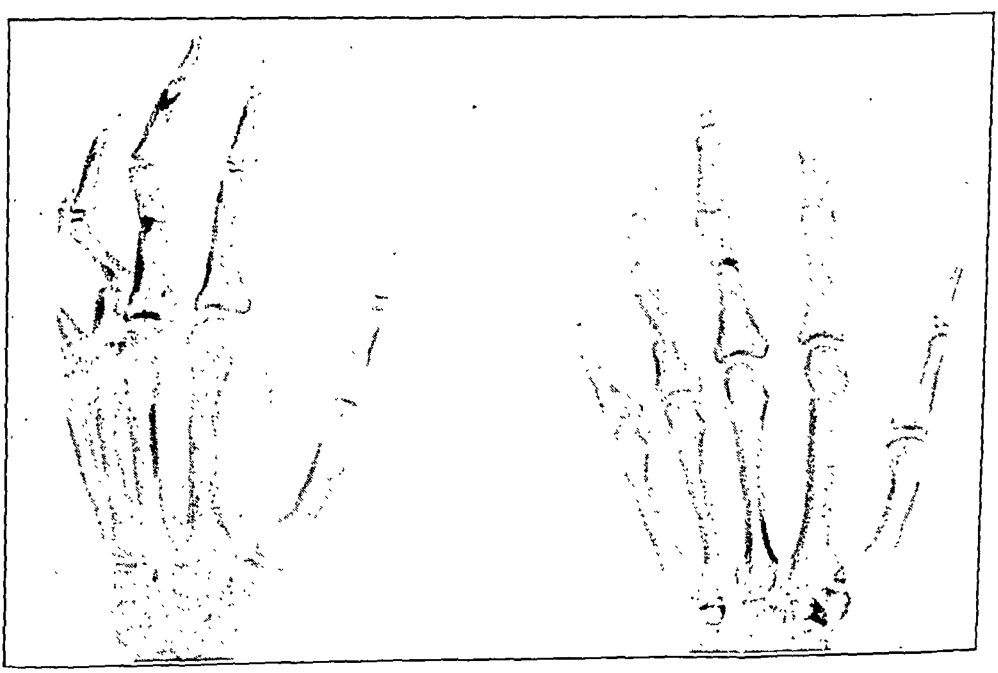

Fig. 1

Case 1. Note the typical anterior angulation involving the proximal phalanges of the third, fourth, and fifth fingers.

* Service of H. C. Frauenthal, M.D.

Fig. 2

Case 1. After reduction. Note the alignment of the fractures of the fourth and fifth fingers; also the moderate dorsal angulation of the third finger. This was corrected by partially extending the metacarpo-phalangeal joint and flexing the proximal phalangeal joint and immobilizing the finger in that position. (See Figure 9-B.) Note the angles between the metacarpals and the proximal phalanges. In the fifth finger, it is 70 degrees; in the fourth, 90 degrees. Note also only partial flexion at the proximal phalangeal joints of the fourth and fifth fingers.

Fig. 2

splints on three contiguous fingers were impractical; moreover, no splint could control the fracture in the fifth finger. Every conceivable method was tried, but without success. A simpler method was then devised which corrected the angulation and provided immobilization. Reduction will first be considered.

CORRECTION OF ANGULATION

Indirect Method

It might be appropriate at this point to call attention to

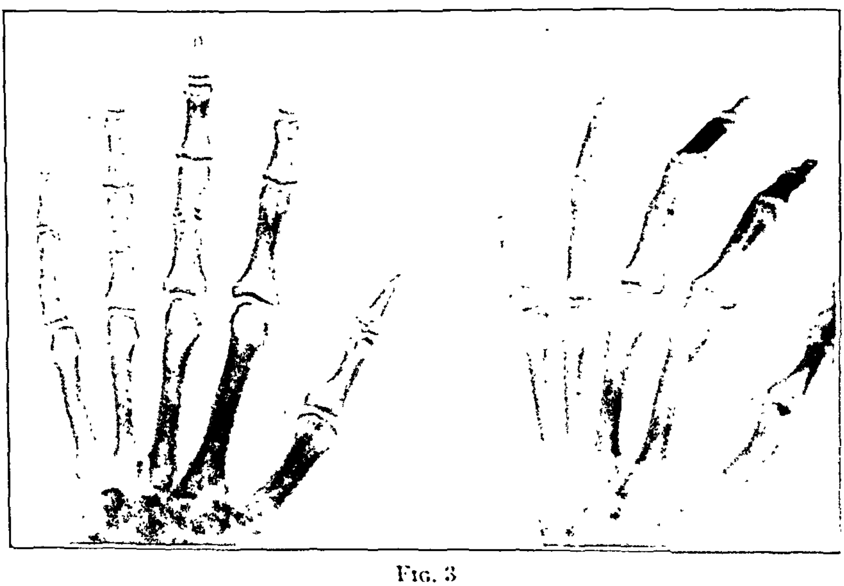

Fig. 3

Case 1. End result: excellent alignment; no angulation.

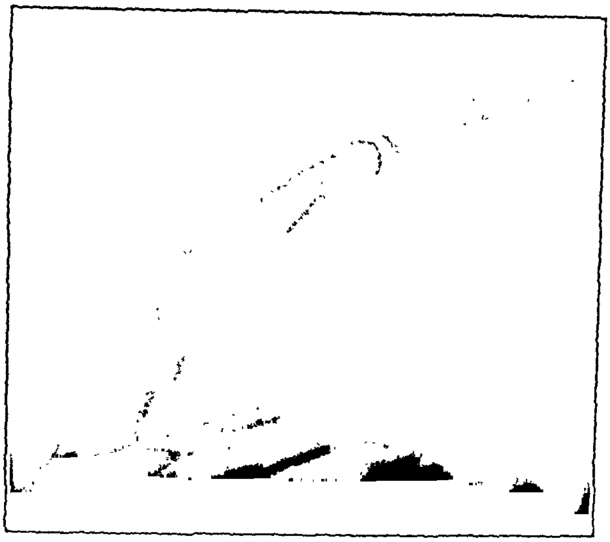

FIG. 4

Case 2. Fracture of the proximal phalanx of the fifth finger. Anterior angulation.

the fact that motion in proximal interphalangeal j is *equal* in *all fingers.* these joints, the angle greatest flexion is about degrees. When this join flexed to its limit, tension the articular (posterior) sule takes place. In the of a fracture of the proxi phalanx, any attempt to this joint further will, thro the taut articular caps only move the head of phalanx toward the palm that is, into flexion. T was demonstrated in Case in which an operation was performed because of a previous maluni Osteotomy was done and the rotation deformity was overcome (Fig. When the proximal phalangeal joint was flexed to its full limit, the dis fragment also went into flexion, and the amount of flexion of this fra ment was in direct ratio to the amount of tension on the articular (p terior) capsule. As soon as this joint was relaxed, the distal fragme went into a position of exte sion, and anterior angulati at the fracture site to

FIG. 5

Case 2. Reduction by partial flexion at the metacarpophalangeal joint and full flexion at the proximal phalangeal joint. The angle between the metacarpal and the phalanx is 135 degrees. Full flexion at this joint would make an angle of 70 degrees.

FIG. 6

Case 2. Anteroposterior view showing excellent alignment.

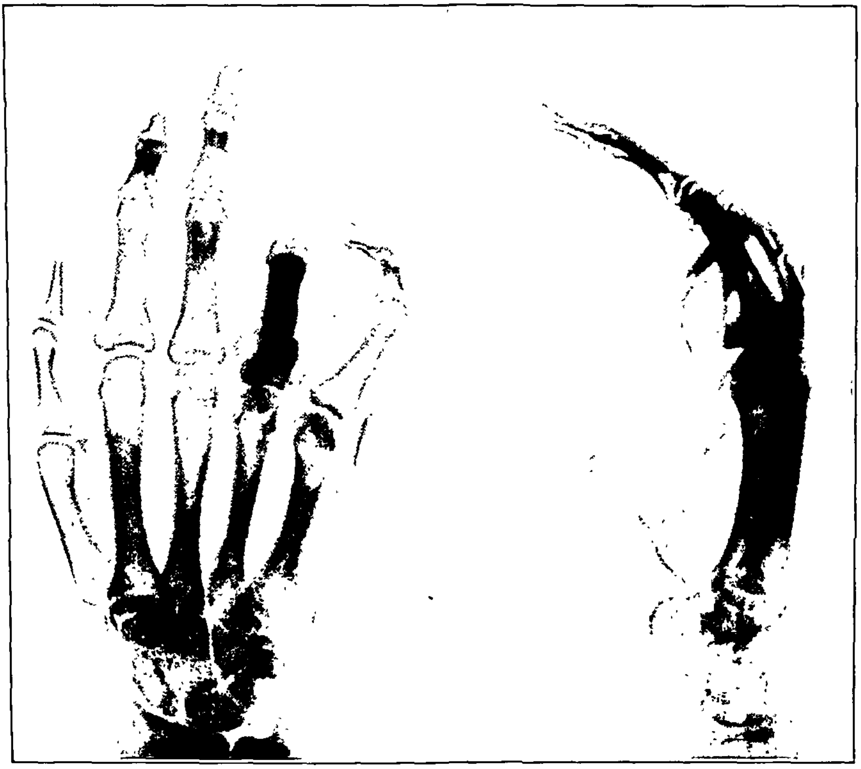

Fig. 7

Case 3. Osteotomy for malunion. Alignment and immobilization were obtained by partial flexion at the metacarpophalangeal joint and full flexion at the proximal phalangeal joint.

place. It was also demonstrated at this time that, if more than slight flexion was present in the metacarpophalangeal joint during these manoeuvers, dorsal angulation took place. This method can control almost all fractures of the proximal phalanges.

Should this procedure prove ineffective, one can then employ direct flexion of the distal fragment.

Direct Method

Direct flexion is obtained by placing the thumb on the anterior angulation and, with the other hand, grasping the head of the phalanx and flexing it. The proper amount of flexion of this fragment is dependent upon the degree of angulation present in the fracture. To prevent any slipping, flexion of the *entire phalanx* is now in order. The expansion of the extensor digitorum communis over the phalanx will splint the fragments, but, as flexion in the metacarpophalangeal joint approaches 90 degrees, tension on the dorsal (posterior) ligament begins to take place. This tension will fix the proximal fragment, and further flexion of the finger will only influence the distal fragment and produce a dorsal angulation,—that is, an overcorrection of the original deformity. Since the angle of

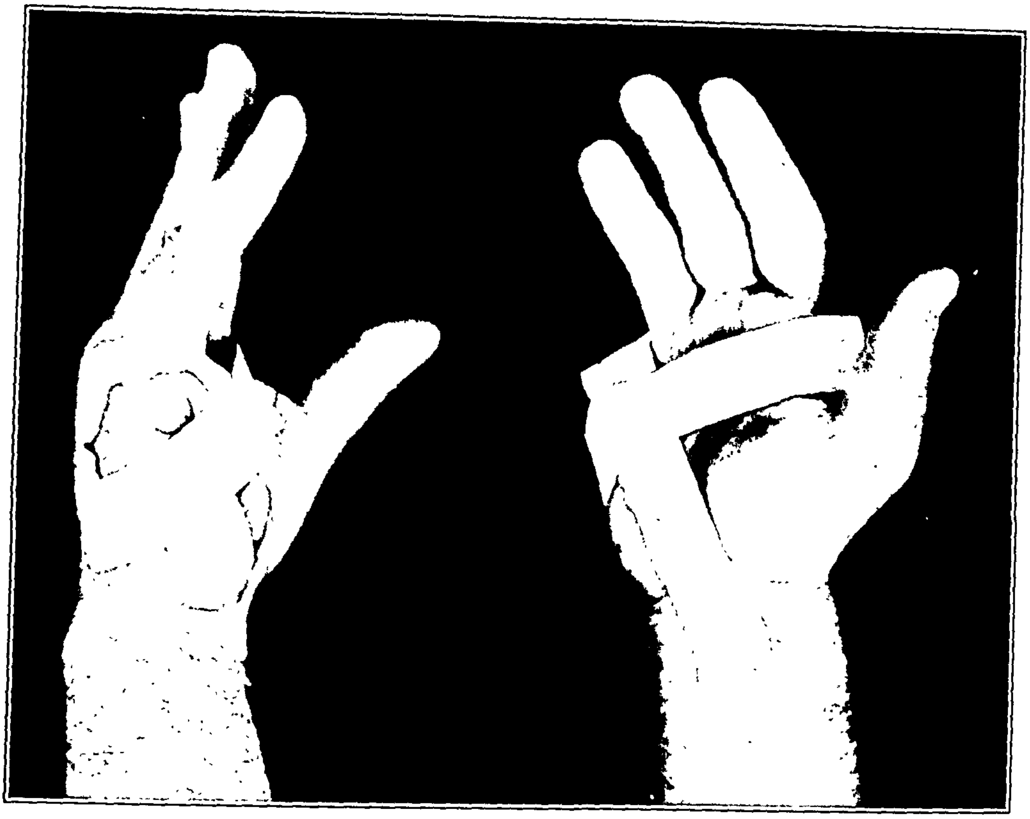

FIG. 8

Strapping. Note *full* flexion at the *metacarpophalangeal* joint and *partial* flexion at the *proximal* phalangeal joint.

greatest flexion in the metacarpophalangeal joints is *not* equal in all the fingers, the amount of flexion will necessarily vary. It is greatest in the fifth finger and gradually diminishes, in order, from the fifth to the second finger, inclusive. The proximal interphalangeal joint must *not* be tensed when direct flexion is used, as such tension would overcorrect the angulation.

IMMOBILIZATION

To secure immobilization, two narrow strips of adhesive are sufficient,—one running from the dorsum of the hand, longitudinally over the finger, to the palm; and the other, transversely across the dorsum of the hand and in the palmar direction over the head of the proximal phalanx or the shaft of the middle phalanx. (See Figures 8 and 9-B.) If there is any space between the palm and the finger, a piece of absorbent cotton may be introduced between them.

For a fracture of the middle phalanx, where an anterior angulation is present, simple strapping of the distal phalanx to the proximal phalanx, with the proximal and distal phalangeal joints in full flexion, will both overcome the anterior angulation and immobilize the fragments (Figs. 9-A, 10-A, and 10-B). In Figure 9-A the strapping on the distal phalanx is too close to the base. Instead it should pass over the finger-nail and around the dorsum and sides of the proximal phalanx close to the web. The principle involved here is basically the same,—*i.e.*, taking advantage

FIG. 9-A

Strapping for fractures of the middle phalanx when *anterior* angulation is present.

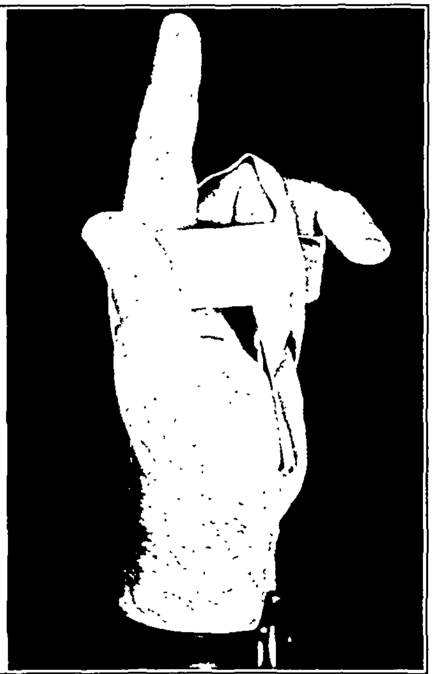

FIG. 9-B

Partial flexion at the *metacarpophalangeal* joint and *full* flexion at the *proximal* phalangeal joint

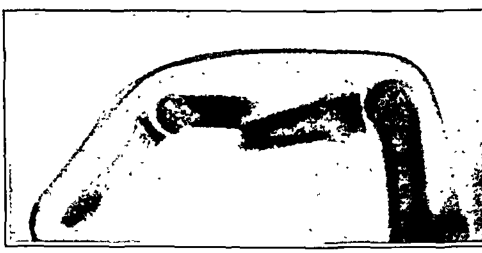

FIG. 10-A

Case 4. Oblique fracture of the middle phalanx with anterior angulation.

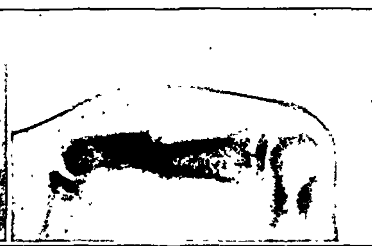

FIG. 10-B

Case 4. Reduction and immobilization by strapping. See Figure 9-A.

of the normal physiological restriction of motion at the proximal and distal interphalangeal joints.

SUMMARY

By utilizing the normal limits of flexion at *either* the proximal interphalangeal *or* the metacarpophalangeal joint, the anterior angulation present in fractures of the proximal phalanges can be overcome. For fractures of the middle phalanx moderate flexion at the *proximal and distal* interphalangeal joints is necessary to accomplish reduction.

Immobilization is accomplished by simple strapping.

The author is indebted to Dr. Louis Sachs and Dr. David Sloane, who treated Cases 2 and 4 according to the author's method.

PANASTRAGALOID ARTHRODESIS

A Study of End Results in Eighty-Five Cases

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From the Department of Orthopaedic Surgery, University of Iowa*

The radical eradication of all joints about the astragalus was first described by Lorthioir and was designed for equinovarus deformity, paralytic or congenital in origin. The technique necessitated the temporary removal of the astragalus, after which it was replaced. The result controlled all deforming factors of the flail foot. This method was modified by Albee and later by Steindler who stressed the applicability of the procedure when quadriceps weakness or paralysis was associated with the flail foot.

In a case of quadriceps paralysis, the patient usually reenforces the instability of the leg in walking by placing the hand on the involved knee, or he relies on a brace which holds the knee in extension. When the foot and tibia are fused in 15 to 20 degrees of equinus and they function as one lever, the pressure of superimposed body weight on the forefoot produces a backward thrust of the upper end of the lever, which passively extends the knee joint to its range limit, thus producing an extremity upon which the individual may place his weight temporarily without danger of collapse of the knee. Two requisites, however, are necessary: the knee joint must allow full extension or a few degrees of hyperextension, and some mechanism must protect the knee joint against ultimate genu recurvatum. This is normally the function of the hamstring muscles and of the capsule of the posterior joint, hence the importance attached to the strength of the hamstring muscles in these cases. In the absence of hamstring action, the capsule assumes the burden unless reenforced by some stabilizing reconstruction as an anterior bone block or a posterior capsuloplasty.

The technique of panastragaloid arthrodesis is as follows: A tourniquet is applied at the midthigh. Through a Kocher incision on the lateral aspect of the ankle, the peroneal tendons and the calcaneofibular and astragaloscaphoid ligaments are severed. The tibiotarsal and midtarsal joints are opened by extreme supination and adduction of the forefoot. This exposes the articular surfaces of the tibia, fibula, astragalus, and scaphoid which, in the order named, are denuded of cartilage with a narrow chisel. The astragalus is then pulled upward and the subastragalar and calcaneocuboid joints are exposed and denuded of cartilage in a similar manner. During the whole procedure the astragalus remains attached by its inferior ligaments. Varus or valgus of the os calcis may

* Service of Arthur Steindler, M.D.

be corrected by appropriate wedges removed from the subastragalar joint. Forefoot abduction and adduction are corrected by wedges removed from the astragalar head and neck. After the astragalus is replaced, the wound is closed and a gutta-percha drain is inserted for twenty-four hours. The foot is placed in 15 to 20 degrees of equinus, in perfect lateral alignment, and immobilized in a long leg cast for three to four months. The patient may then bear weight with no other support than an ordinary shoe.

Of 100 cases of panastragaloid arthrodesis performed for paralytic deformities, eighty-five have adequate details available to make possible the following summary. These patients may be divided into three groups according to their muscular assets at the time of operation.

Group I: Twenty-four patients presented severe paralysis of the entire leg,—poor or absent gluteal musculature, poor or absent hamstrings, absent quadriceps, poor or absent ankle and foot musculature. The results obtained by the operation are tabulated in Table I.

TABLE I

GROUP I—TWENTY-FOUR CASES

Result	Cases *No.*	Cases *Per Cent.*	Average Age (*Years*)	Average Years Observed	Preoperative Findings	*Cases*	Postoperative Findings	*Cases*
Good	10	41.7	13.3	3.3	Calcaneus.....	2	Clinical fusion in good position..	10
					Valgus of foot.	2		
					Varus of ankle.	2		
					No deformity.	4		
Fair	4	16.6	12.7	5	Varus of foot..	2	Hyperextension of knee.......	1
					Varus and cavus of foot.....	1	Necessity for long leg brace....	3
					Metatarsus varus........	1	Clinical fusion in good position.	4
Poor	10	41.7	15.8	2.6	Varus of foot..	4	Varus of knee ...	2
					Varus of ankle.	1	Flexion contracture of knee...	2
					Equinus......	4	Hyperextension of knee.......	1
					No deformity..	1	Pain in ankle ...	1
							Valgus of foot .	2
							No improvement.	2
							Necessity for long leg brace. .	10

Group II: Twenty-five patients presented good gluteal and hamstring musculature, absent quadriceps musculature, and poor or absent ankle and foot musculature. The end results are shown in Table II.

Group III: Thirty-six patients presented good gluteal, quadriceps, and hamstring musculature, with associated paralytic flail foot in the majority of cases. Table III gives the end results.

Results are classified as "good", "fair", and "poor". A good result indicates a stable, painless foot with no necessity for support to the extremity. A fair result signifies improvement in gait without symptoms. A poor result indicates no improvement.

TABLE II

GROUP II—TWENTY-FIVE CASES

Result	Cases No.	Cases Per Cent.	Average Age (Years)	Average Years Observed	Preoperative Findings	Cases	Postoperative Findings	Cases
Good	20	80	12.3	4.3	Varus of foot. .	5	Clinical fusion in good position. .	20
					Equinus.	4		
					Valgus of foot.	2		
					Valgus of ankle	1		
					Cavus.	2		
					Calcaneus. . . .	2		
					No deformity .	4		
Fair	2	8	14	1.5	Varus of foot. .	1	10-degree flexion contracture of knee	1
					No deformity.	1	10-degree equinus with knee instability.	1
Poor	3	12	10.6	4.3	Valgus of foot.	1	25-degree flexion contracture of knee.	1
					Calcaneus. . . .	1	Pseudarthrosis of ankle with pain	1
					No deformity. .	1	Pseudarthrosis of ankle with calcaneus.	1

Although this type of arthrodesis may be considered too radical for Group III, the results were so satisfactory, objectively and subjectively, that the procedure may be considered to be ideal for a flail foot in the case of an active individual of the laboring class. However, other types of stabilization and tendon transplantation might be considered for the nine cases in which the long muscles about the ankle functioned partially. These patients should be candidates for the usual triple arthrodesis and peroneal transplantation. The two fair results and the one poor result are accounted for by errors in technique.

TABLE III

GROUP III—THIRTY-SIX CASES

Result	Cases No.	Cases Per Cent.	Average Age (Years)	Average Years Observed	Preoperative Findings	Cases	Postoperative Findings	Cases
Good	33	91.6	12	4.4	Flail ankle and foot	24	Clinical fusion in good position.	33
					75-per-cent. gastrocnemius strength	3		
					Additional 50-per-cent. peronealstrength	6		
					Severe foot deformity	0		
Fair	2	5.6	8.5	5	Varus of foot . .	1	25-degree equinus	1
					No deformity. .	1	Pseudarthrosis of ankle with pain	1
Poor	1	2.8	15	2	Mild valgus of foot	0	Anterior dislocation of astragalus with pseudarthrosis and pain..........	0

COMMENT

Crainz suggested the age of twelve years as the earliest age at which fusion of this type should be attempted. The youngest patient in this series was six years of age and no apparent difficulty was experienced in obtaining a fusion. There is, however, a good reason for delaying the procedure until the age of twelve years. The relative proportion of the cancellous part of the astragalus as compared to the cartilage is greater at this time and, therefore, the decrease in size after removal of the cartilage is correspondingly less. Hence, there is less shortening of the leg from the operative procedure, whereas fusion at an earlier age would contribute directly to the shortening of the involved extremity. Crainz, like Lorthioir, temporarily removed the astragalus to facilitate removal of cartilage and stated that this was a safe procedure. This step has not been followed in this series as the astragalus has always remained attached by its inferior ligaments, thereby partially preserving its blood supply. One case of apparent necrosis of the astragalus followed the temporary removal of the bone during this type of fusion for a traumatic arthritis in an adult.

CONCLUSION

Considering the entire series, the results were good in 74.1 per cent., fair in 9.4 per cent., and poor in 16.5 per cent. Eight fair and fourteen

poor results were obtained. Of these, sixteen were due to errors in indication, while six were due to errors in technique. It is evident, therefore, that proper selection and surgical technique will produce a stable foot and ankle, which also stabilizes the knee joint. Muscular requisites are good gluteal and hamstring action. Definite contra-indications are disalignment of the knee, such as a valgus, hyperextension, or flexion contracture.

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STABILIZATION OF PATHOLOGICAL DISLOCATION OF THE HIP IN CHILDREN

BY J. B. L'EPISCOPO, M.D., BROOKLYN, NEW YORK

Acute suppurative conditions of the hip joint in early childhood are quite common. In most of these cases a certain degree of absorption of the head and sometimes of the neck occurs, often resulting in a pathological dislocation of the hip or fibrous ankylosis. To the writer's knowledge, no adequate operation has been devised to stabilize such hips when dislocation has occurred. In discussing reconstruction operations of the hip, Campbell and Speed do not consider this type of pathological dislocation at all.

The author feels that the best way to stabilize these hips is to restore in some way the anatomical neck of the femur, so that it with the shaft produces an angle of approximately 125 degrees. The following operation was devised for that purpose.

The hip joint is exposed through the usual Smith-Petersen incision. The upper end of the femur is split from above downward sagittally. The medial portion includes whatever is left of the neck and about one-third of the width of the shaft of the femur. Before making the sagittal section in the femur, one should be sure that the toes point forward; otherwise the foot may be everted or inverted when the medial prong of the fork is placed in the acetabulum. The length of the bone incision depends on how long a neck is needed in each individual case. Then a greenstick fracture of the medial portion of the sectioned femur is produced, and the broken fragment is bent medially so that the upper end fits into the acetabulum. The amount of bending should be sufficient to produce an angle of about 125 degrees between the fragment and the shaft, thus restoring the normal neck on top of the shaft. Then the bent fragment is maintained in position by driving in a wedge of bone at the apex of the cleft between the two prongs of the upper end of the femur. This wedge of bone is taken from the crest of the ilium and is large enough to maintain the broken inner fragment at the desired angle with the shaft of the femur. It should be large enough to be jammed and held in position without the use of any sutures. As the upper end of the bone is placed into the acetabulum, it is best to abduct the limb, as this facilitates the procedure. When the angle is being produced between the broken fragment and the shaft, the extremity is adducted until the proper angle is obtained. It should be borne in mind that adduction tends to separate the two prongs of the fork produced,—that is, to produce a coxa vara; whereas abduction tends to bring the two prongs together,—to produce a coxa valga. The limb is held in the desired position of adduction to maintain the proper relationship while the wound is being closed, and a plaster-of-Paris spica is applied down to the toes. When

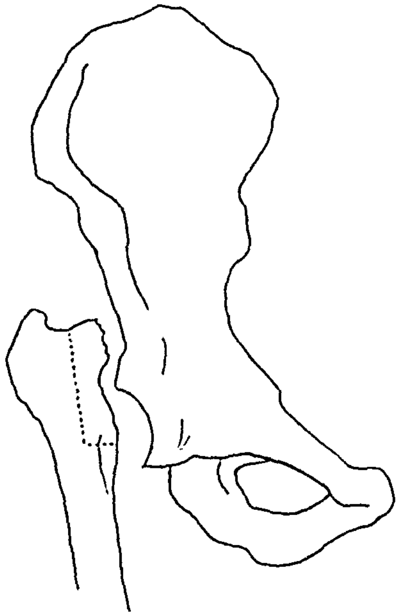

FIG. 1-A

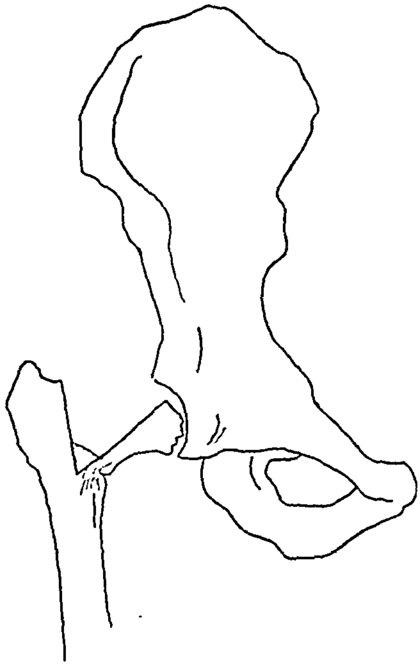

FIG. 1-B

Diagrammatic drawing of hip.
Fig. 1-A: Before operation.
Fig. 1-B: After operation.

the operation is completed, there is a triangular space left between the prongs of the fork. This triangular space eventually fills in with bone, so that the upper end of the femur is eventually a triangular mass of bone, with the upper inner point of the triangle lying within the acetabular cavity. This remains within the acetabulum, thereby preventing any upward displacement of the shaft. In the last case operated upon, the technique was modified by inserting a piece of fascia between the prongs of the fork. This resulted in the production of a true neck, which fitted in the acetabulum, instead of a triangular mass of bone at the upper end of the femur (Fig. 7).

The author believes that the point stressed by Whitman—the maintenance of the normal distance between the origin and insertion of the abductor muscles—is only an academic consideration, as the muscles, particularly in childhood, adapt themselves to the shortened distance resulting from the upward displacement of the femur, except in those very rare cases in which the upper end of the femur has slipped high on the ilium close to the origin of the gluteus medius muscle.

The operation described differs from Albee's bone-muscle-lever operation in that the greenstick fracture of the upper end of the femur is produced on the medial aspect of the femur rather than on the lateral aspect.

Before operating on such cases, we should, of course, try to bring the upper end of the femur to a position as nearly opposite the acetabular cavity as possible, using skin traction or even skeletal traction if necessary. It is also well before operating to have a roentgenogram taken of the hip with and without traction. If the hip comes down sufficiently

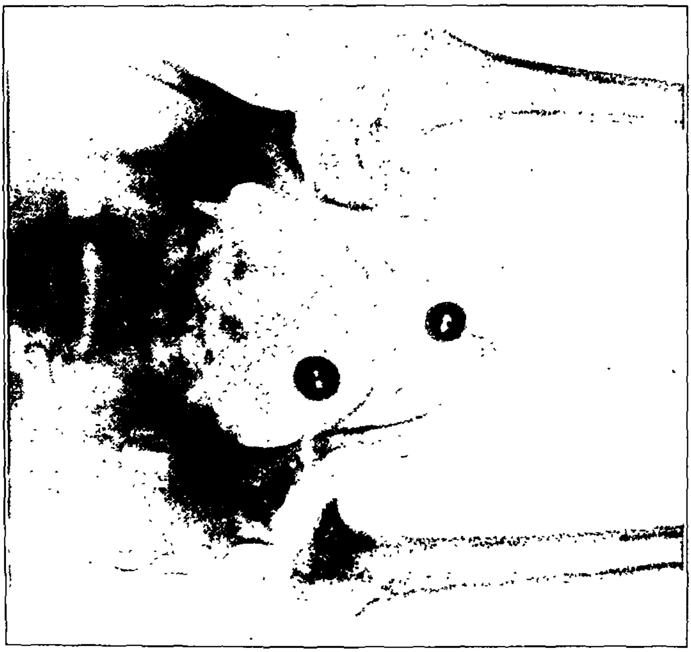

Fig. 3

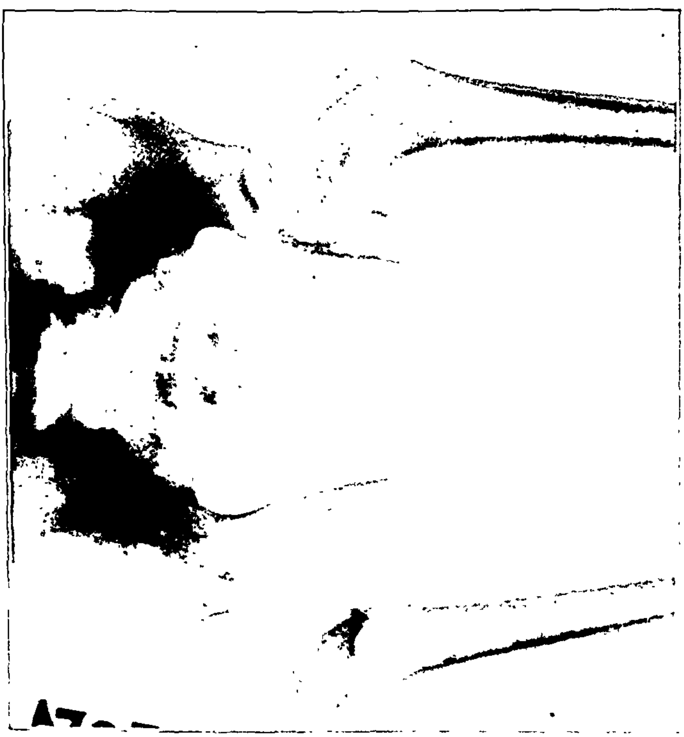

Fig. 2

Fig. 2. Case 1. Before operation.
Fig. 3: Case 1. Over one year after operation, showing triangular formation of the upper end of the femur as described in the text, with the inner point of the triangle well in the hip socket.

with simple manual traction, nothing further is done, but, if it does not come down, then traction is applied to bring it down.

Dislocations of the type under consideration always follow an infection. Therefore, before we attempt to do any reconstructive work, we must be sure that there is no active disease present. However, the operation should be done as soon as possible after we are certain that there is no danger of lighting up any latent infection. The author waits until there is no clinical or roentgenographic evidence of activity before performing the fork operation. In one case the writer operated only nine months after the patient had recovered from acute suppurative arthritis. This seems rather early, but there were absolutely no signs of acute inflammation when the hip joint was opened.

The author believes that this operation should be kept in mind during the treatment of acute suppurative lesions of the hip in cases in which the head of the femur is absorbed. The patient should not be allowed to bear weight on the affected limb, in order to prevent the upper end of the femur from slipping upward. Walking, as soon as indicated, may be

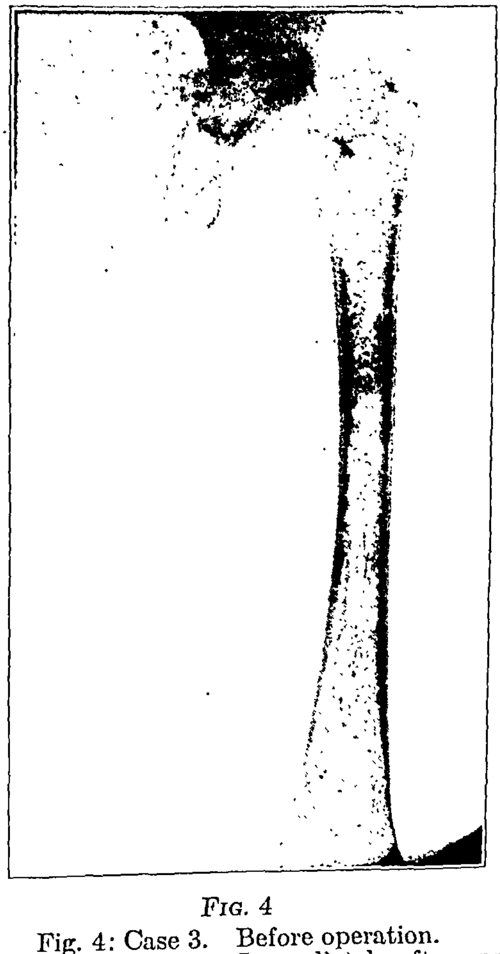

Fig. 4

Fig. 5

Fig. 4: Case 3. Before operation.
Fig. 5: Case 3. Immediately after operation, showing the greenstick fracture of the upper inner end of the femur in the lower portion of the acetabulum. The wedge of bone between the two prongs of the upper end of the femur has shifted some, but the fork position is maintained.

FIG. 7

Case 4. Four months after operation. The child has been walking.

FIG. 6

Case 4. Before operation.

permitted with a Thomas extension brace on the affected side and a raised shoe on the good foot. If this procedure is followed, considerable shortening may be prevented and the later reconstructive operation will be less difficult technically.

The operation was first done for an ununited fracture of the neck of the femur in an elderly patient. The final result in that case was complete absorption of the medial prong of the fork, so that ultimately the patient was left with a flail hip and the operation was, therefore, a total failure. Why the fork absorbed the writer does not know, because it was composed essentially of part of the upper shaft of the femur. Fractures in this region usually unite rather readily. Because of this failure, and fearing a similar result, the writer has not attempted the fork operation again in treating this condition. The subsequent cases have all been pathological dislocations following acute suppurations of the hip, and absorption has not taken place in any of them. The operation is now restricted to this type of case,—pathological dislocation following acute suppuration of the hip in children.

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EPIPHYSIOLYSIS OF THE UPPER FEMUR

A Report of Thirty-Eight Cases

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Epiphysiolysis of the upper femur is by no means a rare condition. At the time of puberty it seems to be the most common cause of hip-joint trouble and, compared with other hip diseases of youth, it holds fourth place in frequency according to the files of our Clinic:

Tuberculosis of the hip	269 cases
Suppurative conditions (osteomyelitis)	71 cases
Perthes' disease	100 cases
Epiphysiolysis	38 cases

Males are more frequently affected than females; in our material we have found the ratio to be twenty-seven to eleven. The average age incidence was twelve and two-tenths years for girls and thirteen and seven-tenths years for boys, which corresponds to the earlier puberty in the female.

Our material showed that constitutional symptoms (indicating anomalies or disorders in the endocrine system) were present in about one-half of the cases. Two constitutional or anatomical types were outstanding: the tall, slender type (six cases), and the rather short, obese type with the characteristic signs of Fröhlich's syndrome (ten cases, seven boys and three girls). In three cases there were signs of healed rickets (funnel chest). In seven cases there was a history of familial obesity.

One case is of special interest. The father of a tall boy with epiphysiolysis had similar but less marked symptoms during his adolescence and was treated with bed rest and physiotherapy. Recent roentgenograms of the father show a coxa vara, which is very likely the end result of an incomplete epiphysiolysis.

These facts point to a constitutional rather than to a traumatic cause. In only seven of our cases was the onset sudden; in the others, onset was insidious and the patients complained of intermittent pain in the hip. It is difficult to say just what pathological process is responsible for the lessened resistance at the epiphysiodiaphyseal junction, for actual pathological reports are few and inconclusive. We have seen in some of the roentgenograms irregularities of the juxta-epiphyseal zone suggestive of disturbed enchondral ossification. In one case (bilateral) we were able to demonstrate cystlike changes in the juxta-epiphyseal area, although the patient was clinically symptom-free at that time. (See Figure 1.) However, epiphysiolysis took place four months later.

* Service of Arthur Steindler, M.D.

TABLE I

Analysis of Thirty-Eight Cases of Epiphysiolysis of the Upper Femur

Case	Sex	Age at Onset (*Years*)	Constitutional Type	Familial Obesity	Side Injured	Degree of Trauma	Mode of Onset	Duration of Symptoms	Inter-mittent Pain	Treatment (Before or After Admission)	Clinical Result	Roentgenographic Findings
1. R. J.	Male	14	Tall		Left	Mild	Gradual	3 weeks	Yes	Manipulation and cast	Good	Early typical; later arthritis. (See Figures 2 and 3.)
2. D. B.	Male	13			Right	Severe	Sudden	2 years	No	None	Good	Compression fracture of epiphysis. Necrosis of head followed by reorganization. (See Figure 5.)
3. S. T.	Male	14	Funnel breast	Yes	Left	Severe	Gradual	1 year	Yes	Cast	Good	Partial displacement. Osteoporosis of juxta-epiphyseal area.
4. E. M.	Female	12	Fröhlich's syndrome	Yes	Right	Mild	Gradual	5 months	Yes	Manipulation and cast	Good	Typical picture.
5. L. H.	Male	11	Fröhlich's syndrome	Yes	Left	Mild	Gradual	2 years	Yes	Manipulation and cast	Good	Irregularities in juxta-epiphyseal area. Good reduction. Coxa vara followed.
6. E. D.	Male	13			Bilateral	None	Gradual	5 years	Yes	Physiotherapy	Poor	Arthritic changes with deformity.
7. G. R.	Male	15	Tall	Yes	Right	None	Gradual	9 months	No	Manipulation and cast; arthroplasty	Poor, ankylosis	Typical. Later, ankylosis and coxa vara.
8. E. J.	Female	14			Left	Mild	Gradual	4 months	Yes	Manipulation and cast	Too recent	Typical. Not a good reduction. Irregularities in juxta-epiphyseal area.
9. J. A.	Male	15			Right	Severe	?	20 years	?	Physiotherapy	Arthritis	Coxa vara and arthritis.
10. B. S.	Male	12	Fröhlich's syndrome		Left	Mild 2	Gradual	10 months	Yes	Manipulation and cast	Excellent	Moderate displacement. Good reduction.
11. R. P.	Male	14		Yes	Left	Mild	Gradual	1 year	Yes	Manipulation and cast	Poor	Typical. Good reduction. Coxa vara.
12. C. H.	Female	11			Right	Mild 2	Gradual	10 months	Yes	Cast	Excellent	Typical. Poor reduction. Coxa vara. Porosis of lower pole.
13. A. G.	Female	14			Right	Mild 2	Gradual	6 months	No	Manipulation and cast	Stiff	Typical. Irregularities in juxta-epiphyseal area. Good bony union

				syndrome									Good bony union.
15.	C. L.	Male	14			Right	Severe 2	Gradual	18 months	?	Open reduction	Fair	Bony union. Coxa vara and arthritic changes.
16.	A. H.	Male	10	Fröhlich's syndrome		Right	Severe	Sudden	10 months	?	Manipulation and cast	Good	Typical. Aseptic necrosis of head. Premature synostosis. (See Figure 6.)
17.	M. W.	Male	12	Tall		Left	Mild	Gradual	2 years	Yes	Osteotomy	In cast	Healed in poor position. Marked arthritic changes.
18.	W. H.	Male	15			Left	None	Gradual	6 weeks	Yes	Manipulation and cast	In cast	Slight displacement. Aseptic necrosis of head. (See Figure 7.)
19.	T. H.	Female	10	Fröhlich's syndrome	Yes	Bilateral	Mild	Sudden	1 year	?	Manipulation and cast	Good	Slight displacement. Rough juxta-epiphyseal area. (See Figure 1.)
20.	R. C.	Male	15			Right	None	Gradual	10 months	Yes		?	Loss of "S" shape. Marked softening in juxta-epiphyseal area. Coxa vara.
21.	E. D.	Male	12	Fröhlich's syndrome		Right	None	Gradual	1 year	Yes	Casts	?	Incomplete lesion. Softening in juxta-epiphyseal area. Complete resolution in 7 months.
22.	L. D.	Male	15		Yes	Left	Mild	Gradual	2 weeks	?	Manipulation and cast	Excellent	Irregularities in juxta-epiphyseal area. Early occlusion later.
23.	V. H.	Male	13	Fröhlich's syndrome		Bilateral	None	Gradual	2 years	Yes	Manipulation and cast	Good	Bilateral coxa vara with arthritis on one side.
24.	R. E.	Male	16			Right	Mild	Gradual	?	Yes	Manipulation and cast	?	Typical. Irregularities in juxta-epiphyseal area.
25.	H. P.	Male	15	Funnel breast		Bilateral	Severe	Sudden	4 years	No	Osteotomy	In cast	Marked deformities and arthritis.
26.	S. S.	Female	11			Right	Mild 2	Gradual	3 months	Yes	Manipulation and cast	Good	Slight coxa vara and irregularities in structure of upper and lower poles.

TABLE I (*Continued*)

Case	Sex	Age at Onset (*Years*)	Constitutional Type	Familial Obesity	Side Injured	Degree of Trauma	Mode of Onset	Duration of Symptoms	Inter-mittent Pain	Treatment (Before or After Admission)	Clinical Result	Roentgenographic Findings
27. E. R.	Female	14			Bilateral	None	Gradual	?	Yes	Manipulation and cast	Fair	Irregularities in juxta-epiphyseal area on one side.
28. A. K.	Male	13	Tall		Right	Mild	Gradual	6 months	Yes	Open reduction and peg	Good	Irregularities in juxta-epiphyseal area. Good bony union and premature occlusion typical.
29. F. S.	Female	13			Left	None	Gradual	?	Yes	None	?	Typical.
30. P. H.	Female	15			Left	None	Gradual	43 years	Yes	None	Arthritis	Marked arthritis. Sclerosis in weight-bearing portions. Slight displacement.
31. R. E.	Male	15	Funnel breast, tall		Left	None	Gradual	4 months	Yes	Cast. To have open reductions	Poor	Typical. Resorption of neck.
32. R. E.	Male	14			Left	Mild	?	26 years	?	Bed rest	Good	Coxa vara and coxa plana.
33. C. B.	Male	11	Fröhlich's syndrome		Bilateral	Mild	Gradual	15 months	No	Manipulation and cast	Too recent	Some osteo-arthritis and irregularities in juxta-epiphyseal area. (See Figure 4.)
34. R. N.	Male	14	Tall		Left	Mild	Gradual	18 months	Yes	Traction; spica for 5 weeks	Fair	Typical and incomplete.
35. C. C.	Male	14			Left	Mild	Gradual	3 years	Yes	Late attempt at manipulation	Poor	Typical picture of a non-reduced epiphysiolysis.
36. P. H.	Female	11		Yes	Right	None	Gradual	18 months	Yes	Physiotherapy and bed rest	Poor	Typical picture of a non-reduced epiphysiolysis.
37. W. H.	Male	16	Fröhlich's syndrome		Bilateral	None	Gradual	7 months	Yes	None	Poor	Typical picture of a non-reduced epiphysiolysis.
38. D. W.	Male	15			Left	None		8 months	Yes	Manipulation and cast	Too recent	Typical picture of a non-reduced epiphysiolysis.

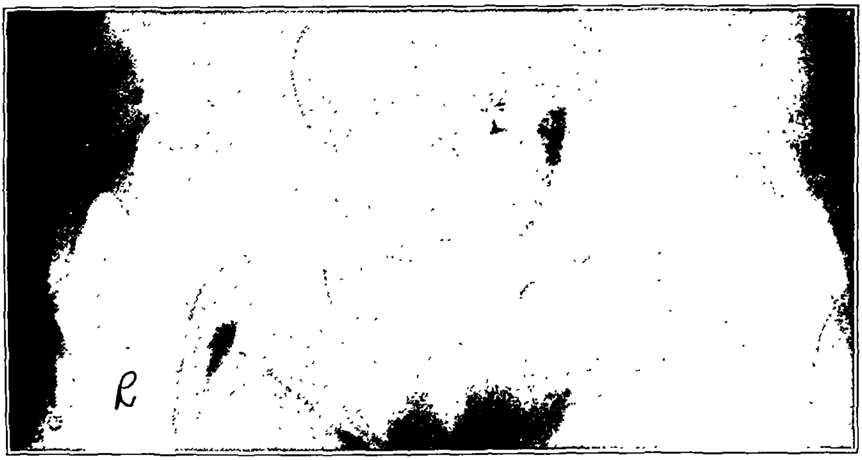

FIG. 1

T. H., female, aged ten. Slight displacement of the right femoral head downward and backward. The left side shows some irregularity in the juxta-epiphyseal portion in the femoral neck. Epiphysiolysis occurred on the left side four months after this roentgenogram was taken.

Enchondral ossification is largely dependent upon the function of the sex glands and hypophysis, for many cases point to a disordered function of these glands. But, if there be a central cause for this abnormal ossification, one should expect to find the same basic pathology in all of the epiphyseal plates. However, it is only the upper epiphyseal discs of the femora that become affected clinically.

The onset of the disease and the relatively high percentage in boys show that epiphysiolysis has probably nothing in common with Perthes' disease, although this also develops on a strongly constitutional basis.

FIG. 2

R. J., male, aged fourteen. Downward and backward rotation of the proximal fragment. The distal fragment is dislocated upward and is almost touching the outer edge of the acetabulum. There is marked outward rotation.

FIG. 3

R. J. One year later than Fig. 2. The lateral pole appears compressed and there is slight lateral subluxation of the head. The bony structure of the epiphysis is irregular and osteosclerotic changes are pronounced. Note the two subchondral cystlike foci of osteoporosis.

Perthes' disease occurs at the ages of from five to seven and the incidence is by far greater in boys.

The typical roentgenogram, showing the downward and backward rotation of the proximal fragment, is well known. (See Figure 2.) As already pointed out, the earlier stages with incomplete displacement may show irregularities in the juxta-epiphyseal portion of the femoral neck (Figs. 1 and 4).

In a typical case of epiphysiolysis one may assume that the periosteum of the neck remains practically intact, and that the vascular supply of the upper fragment is not disturbed. Aseptic necrosis of the upper fragment is an unusual feature and, as far as we know, has not yet been described in this group of *non-traumatic epiphysiolyses*. (See Figures 5, 6 and 7.) Careful examination of the roentgenograms of our cases, however, shows that in five of them aseptic necrosis was present, as evidenced by a dense shadow in the upper fragment.

Follow-up roentgenographic examinations showed the gradual resorption of the necrotic proximal fragment. The upper portion of the femoral head, just below that part of the joint surface which after the displacement of the epiphysis has to bear the body weight, is the last part to become reorganized. This is a point which, in a later stage of the disease (especially if only one roentgenogram is available), makes it difficult to decide whether this dark shadow is a relic of aseptic necrosis or whether it is a reactive sclerosis, due to static stress of weight-bearing. Serial roentgenograms helped to exclude these diagnostic difficulties.

It is interesting that, even though aseptic necrosis of the proximal fragment occurs, reorganization leads to a complete restitution in a relatively short time and without marked alteration in shape. Only in one case did perfect restitution of the head fail to take place. In this case the

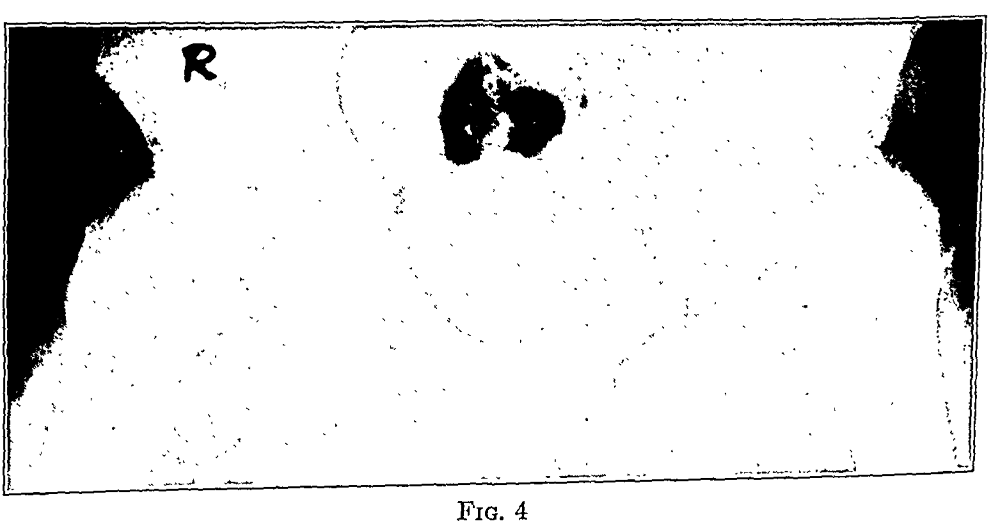

Fig. 4

C. B., male, aged twelve. The changes on the left side indicate an older process. There is distinct evidence of irregularities in the juxta-epiphyseal portions of the necks. The heads show little or no reaction, while the distal fragments, especially that on the left side, show external rotation and anteversion together with some upward displacement.

apex of the head remained separated from the remaining organized tissue by an irregular porotic zone of demarcation. The bone structure of the non-reorganized apex was very dense and the picture was similar to that of osteochondritis dissecans. These few cases of epiphysiolysis, followed by necrosis of the femoral head, are likely to lead to subsequent disturbing changes. This has recently become more widely known, especially in traumatic fractures of the femoral neck in youth.

FIG. 5

D. B., male, aged fifteen. Flattening of the femoral head and marked porosis of its lateral pole. Note the wedge-shaped porotic area at the apex of the head containing a sclerotic fragment and surrounded by osteosclerotic tissue. The epiphyseal plate is indistinct.

The type of treatment is usually dependent upon the stage of the disease. Closed measures, especially Whitman's manipulation as modified by Leadbetter, are likely to be successful in an early stage. In later stages, when the displaced head is already in fibrous union with the femoral neck, forced manipulation can lead only rarely to a satisfactory result. This was true in our series. Our impression is that the position of the femoral head in this situation remains essentially the same and that the tearing of fibrous adhesions (which is followed by newly formed scar tissue) causes an increase in the

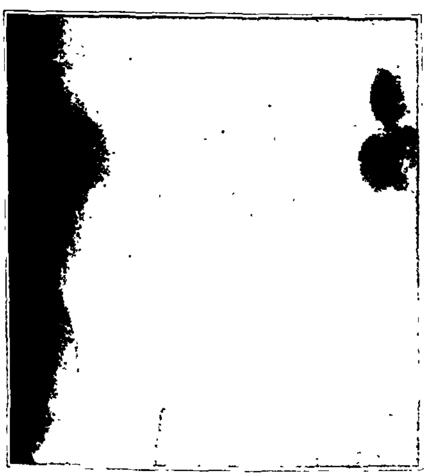

FIG. 6

A. H., male, aged eleven. The medial lower pole and lateral upper pole are extremely porotic. The central portion shows a more or less wedge-shaped area of aseptic necrosis which has not yet undergone reorganization.

FIG. 7

W. H., male, aged fifteen. The dark area of aseptic necrosis is undergoing rapid reorganization from the central portion and from the lateral pole. The joint space is narrowed.

arthritic symptoms. Therefore, we believe that in the later stages of epiphysiolysis open methods are indicated.

Open reduction was performed in three of our cases. In one of these an ivory peg was used to keep the fragments in the corrected position. Results were good in two cases (in the first, no arthritis, good motion, no pain; in the second, no pain, slight limp, flexion to 20 degrees) and in one case poor (ankylosis of the hip; 50 per cent. disability for all kinds of labor).

An arthroplasty of the hip was performed in one case, but bony union followed in good position allowing good symptomless locomotion.

The simplest procedure in older cases is osteotomy to correct deformity and to improve weight-bearing. The subtrochanteric type was done in two instances.

Inveterate cases were given physiotherapy and immobilization in plaster casts, until all arthritic symptoms were alleviated.

THE THERAPEUTIC ACTIVE PRINCIPLE OF MAGGOTS

With a Description of Its Clinical Application in 567 Cases

BY S. K. LIVINGSTON, M.D., F.A.C.S., HINES, ILLINOIS

Considerable reference has been made in the literature during the past few years to growth-stimulating substances [3, 4, 5, 6, 7]. The introduction of maggot therapy in the treatment of chronic osteomyelitis, with its attendant therapeutic-principle theory, has revived the search for such a substance.

Before the World War, chronic osteomyelitis was variously treated. The problem of stimulating granulation tissue to fill the resulting bone and soft-tissue cavities gave rise to the development of various pastes and semisolid substances. Following the War, standardized methods of treatment were evolved,—namely, the Carrel-Dakin method, the Orr technique, and Baer's maggot therapy. These procedures, with their several modifications, are now in general use.

If we pause for a moment to consider the factors underlying chronic osteomyelitis, we have, in the first place, disseminated foci of infection and devitalized particles of bone and medullary tissue, enclosed in rigid-walled cavities throughout the bone. To eliminate these foci, surgery is necessary.

After elimination of foci by operative interference, one is confronted by a large cavity which must be filled by granulation tissue. Therefore, the second factor underlying the affection is the difficulty encountered in obtaining satisfactory healing of this cavity by granulation. The magnitude of this difficulty is appreciated when we realize that bone defects, unless stimulated, heal so slowly that the early formed granulations undergo the changes incident to scar-tissue formation before the bone cavity becomes entirely filled. It is, therefore, evident that, as cicatrization occurs in the periphery, there is a consequent depletion in blood supply which prevents further bone growth and complete healing. One is, therefore, confronted with well-formed scar tissue at the periphery and a cessation of healing in the center.

In view of these considerations, it is evident that the ideal method of treatment for chronic osteomyelitis should have as its basis the following requisites:

1. Thorough surgical removal of diseased parts.
2. Some efficient method of sterilization of the surgically formed wound.
3. Some method of removal of the wound discharges and sloughed tissue that occur subsequent to operation.
4. Some agent that will produce uniform and rapid growth from the bottom, to cause complete filling of the cavity before circulatory changes, incident to scar formation, occur.

With these criteria in mind, it is now opportune to examine the effects of the various methods of treatment mentioned. The Carrel-Dakin, the Orr, and the maggot therapies are all based upon a thorough saucerization of the affected part,—that is, a surgical procedure to remove all devitalized bone, overhanging ledges, and grossly infected soft tissues. Beyond that, the underlying principles are different.

At the time of the introduction of the Carrel-Dakin method, it was thought that the efficacy of the treatment was due to chemical sterilization of the wound. This was subsequently disproved, for inert solutions such as physiological saline, used with the same minute technique, produced the same results. It became evident, therefore, that the value of the treatment lay in the physical removal and possibly the chemical solution of the wound discharges. This method, however, meets only two of the four criteria proposed for the ideal method of approach to the treatment of chronic osteomyelitis,—namely, the thorough surgical removal of all diseased parts and the mechanical and chemical removal of wound slough and discharges.

The Orr technique is based upon a thorough surgical removal of all diseased parts. The vaselin pack acts as an efficient method of drainage. In addition, the physical resistance offered by the pack and the physiological rest incidental to immobilization in plaster-of-Paris aid wound healing which must be spontaneous, for there is no active agent to stimulate growth. The infrequent dressings prevent reinfection, but no efficiently active measure is introduced to sterilize the wound or to stimulate repair. Subsequent to the introduction of the method, it was realized that, in accordance with the experiments and theories of D'Herelle and Besredka, spontaneous sterilization occurs through the formation of bacteriophages. More recently, Albee has added to this method by attempting to sterilize the wound by the administration of a stock or an autogenous bacteriophage. This method, therefore, meets all of the criteria save the last—stimulation of growth—for which no provision is made.

Maggot therapy meets all of the criteria. First, there is a thorough surgical removal of the diseased area; second, the wound is actively sterilized by the maggots which physically remove micro-organisms by ingestion; third, the proteolytic activity of the maggot enzymes breaks down the wound discharges and sloughs into end products, which are then consumed by the maggots; and fourth, the therapeutic active principle of maggots stimulates rapid growth. The isolation, development, standardization, and clinical use of this active principle has resulted in the production of a needed clinical growth-stimulating substance, which has been used by the author in 567 cases of chronic osteomyelitis, chronic leg ulcers, compound fractures, and other similar suppurative lesions.

It was formerly supposed that maggots were effective because of: their mechanical action, rapid movement, and the ingestion and digestion of bacteria and necrotic material, which render such matter inert; stimu-

lation of a rapid outpouring of blood serum, which is healing; and the rapid increase of the pH of the wound. Under close observation, it has been noted that, in the early stages of treatment (after the first to third applications), the maggots live until replaced. As the treatment continues, the maggots live for a decreasing period, and, after the fifth application, the maggots live only a few hours. Death occurs because the pH of the wound has increased and because some substance has been produced through the contact of the live maggots with the tissues which so increases in virulence that, with time, it kills the maggots by its potency. For want of a better name, we have called this substance a therapeutic active principle.

All through this work our attention has been continually focused on the fact that it was not mere mechanical action of the maggots that was primarily responsible for the beneficient results obtained by their use. Animal experiments showed that this additional agent which was developed through the contact of the maggots with the living tissues was, in itself, a curative agent. That an additional agent was responsible for effecting a cure seemed clearly demonstrated by the use of filtered extracts from the bodies of crushed larvae. These observations pointed to the presence of some substance which, in itself, was sufficiently powerful to overcome infections and to permit a normal pH balance to be established. Our opinion was further warranted from the fact that filtered, uncontaminated products derived from the bodies of larvae in culture, when brought into contact with pyogenic organisms in petri dishes, attenuated the cultures.

The factors which determine the efficacy and success of any postoperative treatment consist of:

1. The removal of all sources from which continuing or repeated reinfection can take place.
2. Rigid attention to postoperative detail.
3. Intimate contact between the infected surface and the medium used.

In cases of osteomyelitis, complete removal of all sources from which continuing or repeated reinfection can take place is possible in only a very small percentage of cases in which a shallow localization of the process has occurred. Only in these cases which result in a shallow, wide wound after operation, into which antiseptic solution can be adequately instilled, can the Carrel-Dakin or bipp treatment be successful.

Because of the lack of recognizable characteristics, it is frequently impossible to remove completely the diseased tissue, to guard against the formation of subsequent sequestra, to remove entirely all infected thrombi, or to prevent or to control blood infections—all of which are potent and potential causes for the continued reinfection of the wound. To overcome these difficulties Orr recommends a vaselin pack and Baer recommended maggots.

ORR METHOD OF TREATMENT

In a large number of cases, after the requisite thorough osteotomy, the wound was packed wide open with vaselin gauze, according to the method of Orr, and allowed to granulate under the pack until the surface was very healthy looking to the naked eye. This was followed in some cases by a strapping together of the lips of the wound with adhesive which was left undisturbed for from seven to ten days. At the end of that time it was found that complete healing had taken place in some cases. Smears taken from these wounds at the time of the strapping showed that organisms were present; in many of the wounds, the number of organisms exceeded that accepted as the orthodox minimum for the secondary closure. In many of these cases, treated by Orr's method, healing takes place at either pole of the wound with the persistence of a small sinus near the center. On the other hand, the retention of even a few bacteria, as determined by smears, accounts for the persistence of the sinus, or for a recurrence in a certain number of these cases. For the bacteria, few though they may be, when encysted in the tissues of the wound, are liable under the proper stimulus to assume a renewed activity and to cause a subsequent suppuration and reopening of the wound or a failure of closure of the sinus. In children the Orr method of treatment was successful in a higher percentage of cases than in adults.

Under these conditions, it behooves one to take cognizance of the sources of failure which are inherent because of the nature of the disease process in a tissue as peculiar as bone.

MAGGOT THERAPY

In a previous part of this discussion it was indicated that, because of lack of recognizable characteristics, it is frequently impossible to remove completely the diseased bone at the time of operation, to guard against the subsequent formation of sequestra or necrosis, or to remove completely all infected thrombi,—all of which play important rôles in the continued reinfection of the wound. By the employment of maggot therapy—which consists in (1) living maggots, (2) maggot active principle, and (3) a combination of these accompanied by autogenous vaccine given postoperatively—the operative procedure is continued,—that is, the work of the surgeon is supplemented. The small microscopic areas of infection which it is impossible to see at the time of operation are subsequently and continuously removed, thereby decreasing the potential causes of a continued or subsequent reinfection of the wound. Maggots are living antiseptics and they are especially useful in the large percentage of cases in which a molecular necrosis takes place.

Maggot Active Principle

Maggot active principle, derived from maggots of the *Lucilia sericata*, is a growth-stimulating substance. It is not simply a combina-

tion of picric acid and calcium carbonate to form calcium picrate, as described by Stewart, nor allantoin, as described by Robinson. This has been proved by clinical trial, and can be understood better when we realize that maggots are fly embryos and, therefore, of necessity are rich in complex organic substances which, because of their embryonic nature, are growth stimulating. Maggot extract can be considered best as a complex radical composed of organic embryonic substances, calcium carbonate, allantoin, and the sulphydryl radical. A review of the literature on any one of these substances will reveal growth-stimulating properties; therefore it is understood how these substances, when introduced in combination into a wound, would bring about growth stimulation.

Vaccine Therapy

In association with maggot therapy, because of the large percentage of cases which are hematogenous, a course of vaccine therapy is administered. This consists of polyvalent vaccine of pyogenic organisms suspended in the maggot active principle as a vehicle. The vaccine is administered every fourth day intramuscularly in doses varying from one-tenth of a cubic centimeter to one cubic centimeter, unless untoward effects are observed.

End Results

Of the 567 patients treated by maggot therapy, 88 per cent. were improved and were discharged from the hospital without discharging sinuses. The cavities were completely filled with pink, healthy granulation tissue. This degree of success was 38 per cent. higher than in control cases treated by other methods. The period of healing and convalescence was also shorter when the maggot method of treatment was used.

No method of treatment, however, has seemed to give any assurance that a recurrence of the bone lesion will not subsequently take place. The healing of any bone wound is beset by many opportunities for the retention of dormant foci of infection or small septic sequestra, or by other factors which are always capable, under the proper stimulus and environment, of causing secondary inflammatory reaction in the neighborhood of the original wound. However, the maggot method of therapy offers the least possibility or opportunity for the conditions which cause a recurrence to take place subsequently.

CONCLUSION

In the treatment of chronic osteomyelitis, compound fractures, chronic leg ulcers, and similar pyogenic infections, maggot therapy—consisting of living maggots, maggot extract, or the combination of these—has proved 38 per cent. more effective than other forms of treatment.

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FRACTURES OF THE SUPRACONDYLAR PROCESS OF THE HUMERUS

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Of considerable interest from the anthropological viewpoint have been the incidence and racial distribution of the supracondylar variation in human beings. For a number of years Terry and his associates [1,2,3,6] have been studying the occurrence of the supracondylar process in various races and social strata.

The supracondylar process is a bony projection, of variable size, which is found about two inches above the medial epicondyle of the humerus. It springs from the medial surface of the shaft, near the anterior margin, and is directed downward, forward, and medially toward the medial epicondyle. It is joined to the medial epicondyle by a band of fibrous tissue.

Through the ring formed by the fibrous band which joins the supracondylar process with the medial epicondyle pass the brachial artery and median nerve. In some cases only the nerve is found within it. This ring corresponds to the supracondylar foramen of lower animals. Terry [5] states that this process gives rise to the pronator teres, and occasionally affords insertion to a persistent lower part of the coracobrachialis.

The incidence of the supracondylar process of the humerus is very low. The percentage of incidence, as given by different authors, varies. Terry [3] has given the incidence in the white race as 1 per cent., while other authors give from 0.6 per cent. to 2.7 per cent.

The purpose of this paper is to call attention to this vestigial structure from a clinical standpoint. Because it is rare, many clinicians are not aware of its occasional presence, and, when it is encountered, it is not recognized. It is frequently regarded as a pathological condition of the bone rather than as a normal anatomical variation.

When the process is long, it may easily be fractured and give rise to a great deal of pain. The palpation of a tender, bony projection on the medial aspect of the humerus, just above the elbow, should strongly suggest the presence of a fractured supracondylar process rather than an avulsion of a portion of the shaft. The palpation of such a structure some time after the history of injury should not suggest an old fracture of the humerus with exuberant callus formation, nor should it be termed an "exostosis".

In order to ascertain whether or not this process is present, the examination should be conducted as follows. The patient should be seated

* Service of D. I. Aller, M.D.

facing the examiner with arms bared. With the fingers of one hand, the examiner palpates the lower half of the shaft of the humerus; with the other hand, he holds the patient's wrist and moves the forearm passively to secure optimum relaxation of the muscles of the arm. The anterior aspect of the lower fourth of the humerus and the medial epicondylar ridge should be explored during each examination.[3]

Roentgenologists rarely demonstrate the presence of the process in routine views of the humerus, because when ordinary plates are taken the process is usually not in profile. When the process is suspected, a slightly oblique view puts it into sharp profile. Often a second view is necessary to verify the findings in the first.[8]

If there has been an injury to the process, and it is causing marked pain, the treatment is removal. This is accomplished very simply by making a short incision directly over the process and by exposing it down to the shaft of the humerus, where it may be either cut or broken off and the base smoothed. Care must be taken not to injure the brachial artery or the median nerve, which lie close to the base of the process. These structures are easily retracted and protected.

The following cases are reported in the hope that they may help others to identify fractures of this process.

CASE 1. The first case seen by the author was that of a Mexican female, thirty-eight years of age. She was a transient and had suffered a compound fracture of the nose and a fractured left clavicle in an automobile accident. In making his examination, the admitting physician noted the recent injuries. In addition, he palpated a bony mass on the inner aspect of the left humerus, just above the elbow. The patient stated that she had been injured there a few years previously, but had had no pain in that region since that time. Roentgenograms showed an elevation on the inner aspect of the humerus, about two inches above the elbow. A tentative diagnosis of healed fracture of the distal third of the left humerus was made. The patient was seen on the ward and examination revealed a supracondylar process. Further roentgenograms brought into profile a long supracondylar process (Fig. 1). The process showed definite rotation, which would indicate that the previous injury described by the patient was undoubtedly a fracture of this process. Other members of the patient's family were unavailable for examination to determine the factor of heredity.

FIG. 1

Case 1. Roentgenogram showing healed fracture of the supracondylar process, with rotation.

That this variation was found in a Mexican, who is a hybrid Indian-white, is of interest, for the structure is exceedingly rare in the colored races.[8]

Case 2. The second case seen by the author was that of a fifteen-year-old white male. He was a high-school athlete and had been having considerable pain whenever the inner aspect of the left humerus was struck. Friction against the body was painful. Five years prior to admission, he had been struck on the left arm, and had had considerable pain at the time. It was then that a bony projection on the inner aspect of the left humerus was first noticed. Recently, the protrusion had again become extremely painful. His family physician sent him to the writer with the diagnosis of "bony exostosis" of the left humerus. The presence of a supracondylar process was easily determined by palpation, for the process was unusually long. Because palpation was very painful, the diagnosis of fracture was made. Roentgenograms showed in profile a long supracondylar process, with a definite fracture line visible just beyond the midpoint. Callus formation could be clearly seen (Fig. 2). At operation, a ribbon-like supracondylar process, two and seven-tenths centimeters long, was removed. At the junction of the outer and middle thirds was an imperfectly healed fracture, with excess callus formation. Other members of this patient's family were examined, but no trace of the process could be found in them.

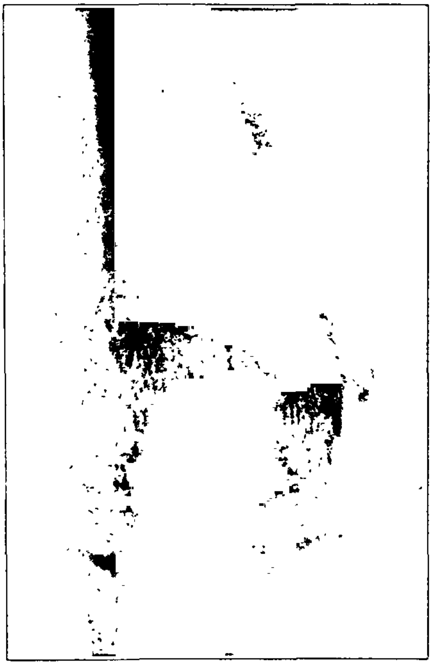

Fig. 2

Case 2. Roentgenogram showing a long supracondylar process with a definite fracture line visible just beyond the midpoint. Note callus formation.

SUMMARY

The incidence of the supracondylar variation in the white race is about 1 per cent.

Clinicians are apt not to be aware of its occasional presence, and hence fail to diagnose injuries to the process.

Treatment for painful fractures is removal of the process.

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TURNBUCKLE BRACE

A Three-Point-Pressure Brace for the Corrective Treatment of Ambulatory Cases of Scoliosis

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There is in any orthopaedic clinic a certain group of patients with scoliosis whose spines are so flexible that at least partial correction of the curves can be obtained by manual pressure on the ribs and pelvis. Apparatus is desirable which can maintain that correction and also allow the patient to be ambulatory. Many devices have been used. Schanz has described a great variety of braces and corsets. The Brewster turnbuckle jacket, the butterfly brace, the Chambers brace, and some form of the Abbott jacket are the chief types of apparatus used today which make some effort at correction of deformity.

If such an apparatus is to be generally useful, it should conform to the following requirements: It should be comfortable. It should not unduly restrict the respiratory excursion of the ribs or limit hip motion. It should be constructed so that it may be easily put on and adjusted either by the patient or by the attendant. It should not require too frequent repairs or complete change because of the growth of the patient.

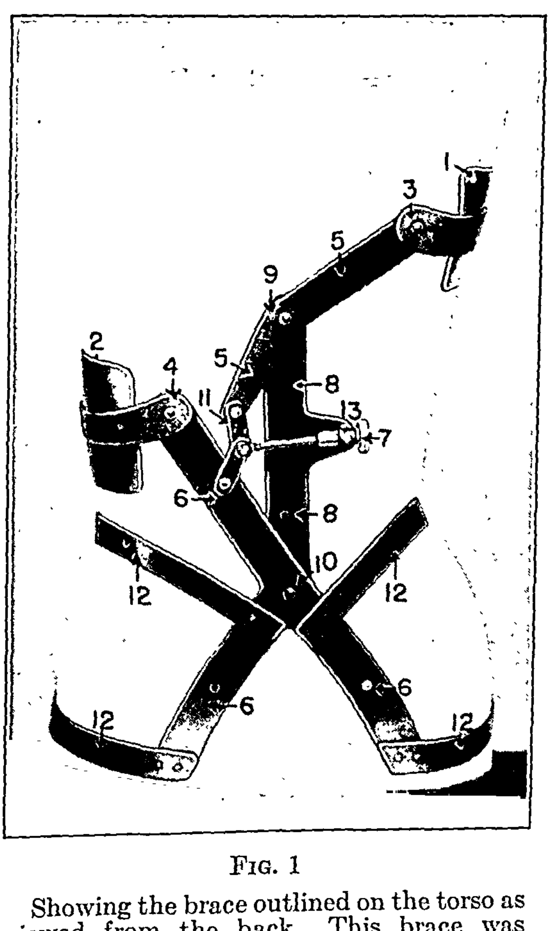

Fig. 1

Showing the brace outlined on the torso as viewed from the back. This brace was designed for the patient shown in Figs. 4, 5, and 6.

If such an apparatus is to be efficient in the correction of the scoliosis, it should fit snugly over the pelvis and iliac crests, these structures being used as the foundation from which the brace derives its lift. This is most important. No brace can efficiently correct scoliosis if it is not prevented from slipping by its firm grasp on the pelvis. In addition, the corrective force applied to the ribs should be easily adjustable and should be ap-

plied in two directions.

The brace shown in Figures 1, 2, and 3 seems to fulfil these requirements most satisfactorily. Since August 1935, thirty-three such braces have been made. In no instance has the use of the brace *failed* to obtain as much correction of the curvature as could be secured manually. Patients who have worn other types of apparatus previously state that this brace is more comfortable. The physicians who have seen the brace in use have been pleased with its simplicity and its effectiveness. The three corrective forces are applied by tightening one screw which exerts pressure on the ribs and pelvis in the directions which are most effective in the correction of the curves. The amount of correction is immediately observable clinically. The changes in the rib rotation, curvature of the spine, and elevation of the shoulders are not masked by the apparatus. The amount of correction can also be checked by roentgenograms taken with the patient in the standing position with the brace on.

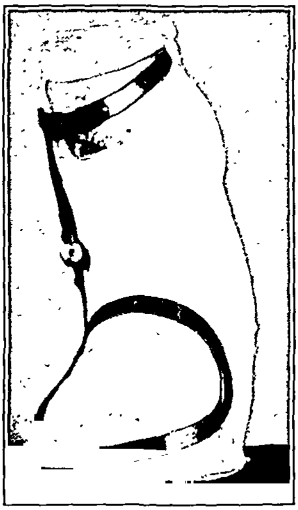

FIG. 2

Right side of the torso, showing the fitting of the pelvic piece and the upper pressure pad.

FIG. 3

Torso as viewed from the left, showing the lower pressure pad fitted to the ribs.

Figure 1 shows the brace as viewed from the back before being covered with leather. This particular brace was built to correct a left dorsolumbar scoliosis. By tightening the screw (*7*), pressure is transmitted to the torso at three points:

1. The upper chest pad (*1*), which fits immediately below the shoulder, moves *upward* and inward, tending to lift the shoulder and to exert pressure inward and slightly backward on the upper ribs.

2. The lower chest pad (*2*) moves inward and forward against the posteriorly rotated ribs.

3. The right iliac crest is pushed downward through pressure exerted in that direction by the pelvic piece (*12*).

It is thus evident that correction of the curve is obtained by means of a free upward lift on the concave side and an inward and forward pressure on the convex side of the curve at its apex.

The brace is constructed as follows.* A plaster-of-Paris model is

* The pelvic steels are made of 18-gauge spring steel. The other steels are 15-gauge with the chest pads (*1* and *2*) made of 18-gauge aluminum reenforced with 15-gauge spring steel. The turn nut is made of brass, and the screw is of 10/32-gauge Bessemer steel.

made with the patient standing; the curves are partially corrected by traction with a head sling. Particular attention is paid to outlining the iliac crests. The wrapped model is filled with plaster and a torso is thus made. The torso is smoothed down. A leather pelvic girdle is then strapped on the torso and allowed to dry. It extends from about the level of the umbilicus to the symphysis pubis. The brace is then outlined on the torso. The Y-shaped arm (*6*) is placed first and then the pelvic steels (*12*) are fitted so that they come about one inch in front of the anterior-superior spines. *If any pressure comes on the spines, the brace is uncomfortable* and has not been made properly.

The optimal points for pressure on the chest have been determined by examination of the patient. The lower pad (*2*) is fitted to the torso and is attached to the arm (*6*) through the free joint (*4*). The toggle bar (*8*) is then fitted. Its upper end comes to the level of the seventh or eighth dorsal vertebra. The lower end of the toggle bar is attached to the

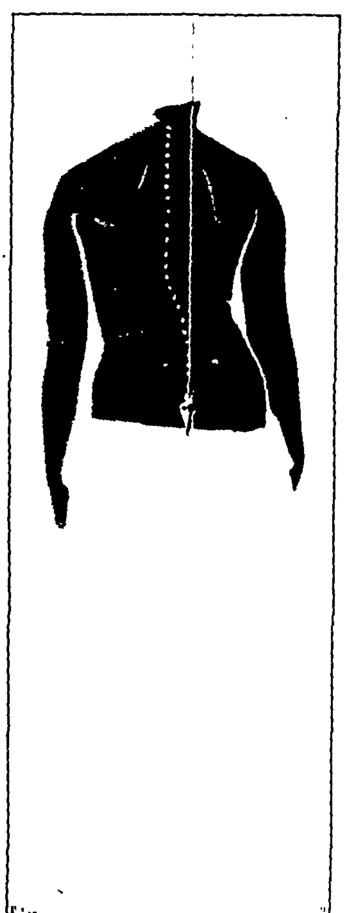

FIG. 4

Case 1. Patient with a left total scoliosis. The spinous processes have been outlined. The amount of list of the trunk is indicated by the suspended plumb-bob.

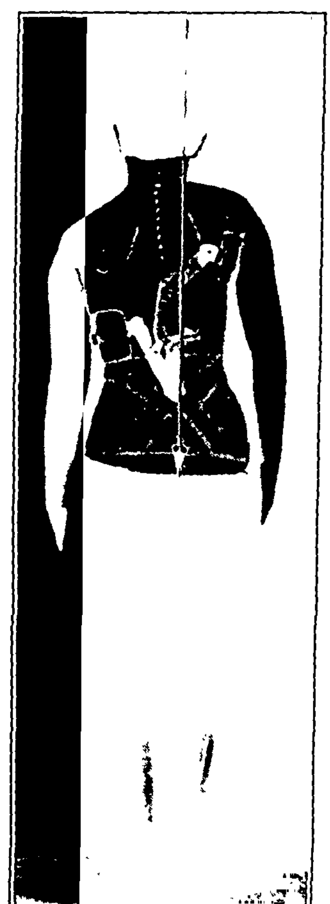

FIG. 5

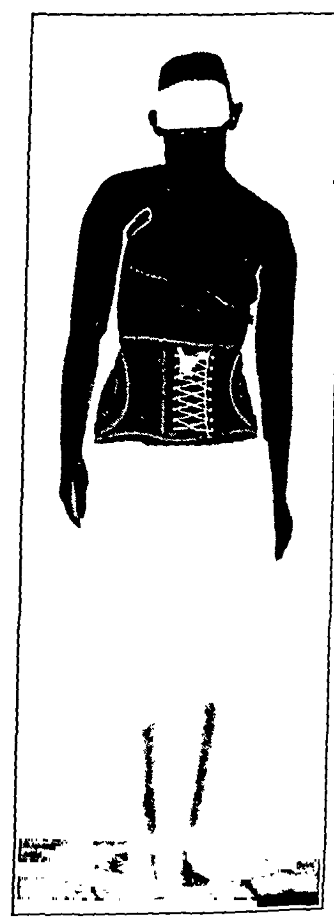

FIG. 6

Showing the amount of correction obtained by the brace. Note the secure fit of the pelvic piece on the iliac crests and the complete freedom of the chest. By abdominal restraint, the brace encourages "chest breathing" and self-correction of the chest deformity.

Y piece (*6*) at the level of the lumbosacral junction by the free joint (*10*). The center of motion is the point at which the turn screw crosses the toggle bar (*8*) and should be located at a little below the apex of the curve.

The upper pressure pad (*1*) is then applied. It is shaped so that its upper and anterior part will act as a crutch under the axilla. The crutch has in effect the tendency to pull the shoulder well back. The upper lever arm (*5*) is joined to the upper pressure pad (*1*) through the free joint (*3*) and is attached to the toggle bar (*8*) by the free joint (*9*). The screw (*7*) pulls through the swivelled collar (*13*) which is attached to the toggle bar (*8*). The pull is transmitted to the lever arms (*5* and *6*) by the joint (*11*).

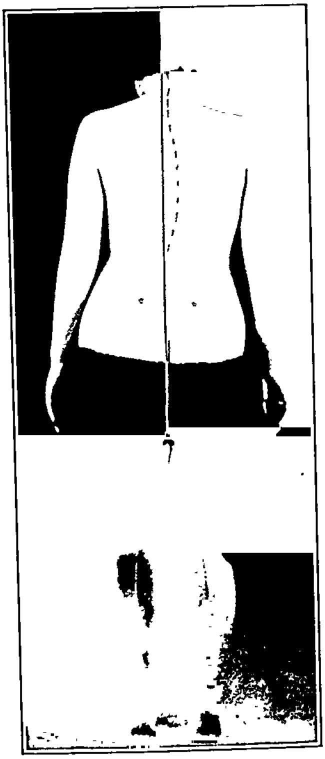

FIG. 7

Case 2. Patient with a right-dorsal left-lumbar structural scoliosis.

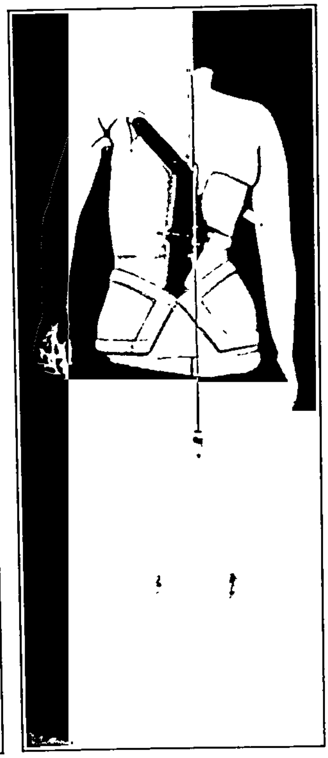

FIG. 8

Case 2. Showing the amount of correction obtained by the brace. Note the downward thrust on the left iliac crest and the upward thrust beneath the left axilla, with resultant widening of the intercostal spaces and filling out of the sulcus between the ribs and pelvis.

The pressure pads are covered with leather or chamois. The brace is then sewed on to the leather pelvic girdle. A leather strap connects the upper and lower pads across the chest.

It will be noted that the toggle bar, freely jointed at both ends, remains fixed in position and *does not move* when the screw is tightened.

The relative lengths of the lever arms (*5* and *6*), as well as the ratio of leverage on each arm, are varied to meet the specific indications for the case in question.

The brace has been found to be particularly valuable in the correction of the pelvic tilt and scoliosis resulting from imbalance of the trunk muscles in infantile paralysis. The single flexible curve of a functional scoliosis is equally satisfactorily corrected. Certain cases of structural scoliosis with double curves can be benefited by the use of this brace if the curves are flexible.

FIG. 9

Case 2. Roentgenogram taken with the patient in the standing position.

SUMMARY

The comfortable brace which has been described applies effective three-point pressure for the correction of spinal scoliosis. It does not unduly restrain the patient. Chest expansion is not restricted. The corrective force is obtained by tightening only one screw which is permanently attached to the brace and which transmits the force to the chest and pelvis by a very powerful leverage through a toggle bar. This brace is most effective in the correction of single flexible curves, but it is also applicable in certain cases of structural double curves which are not fixed. Operative procedure and exercises are not supplanted, but supplemented by this brace.

The authors are indebted to Dr. Paul Norton and Dr. Louis Nathan for many helpful suggestions in the development of the brace.

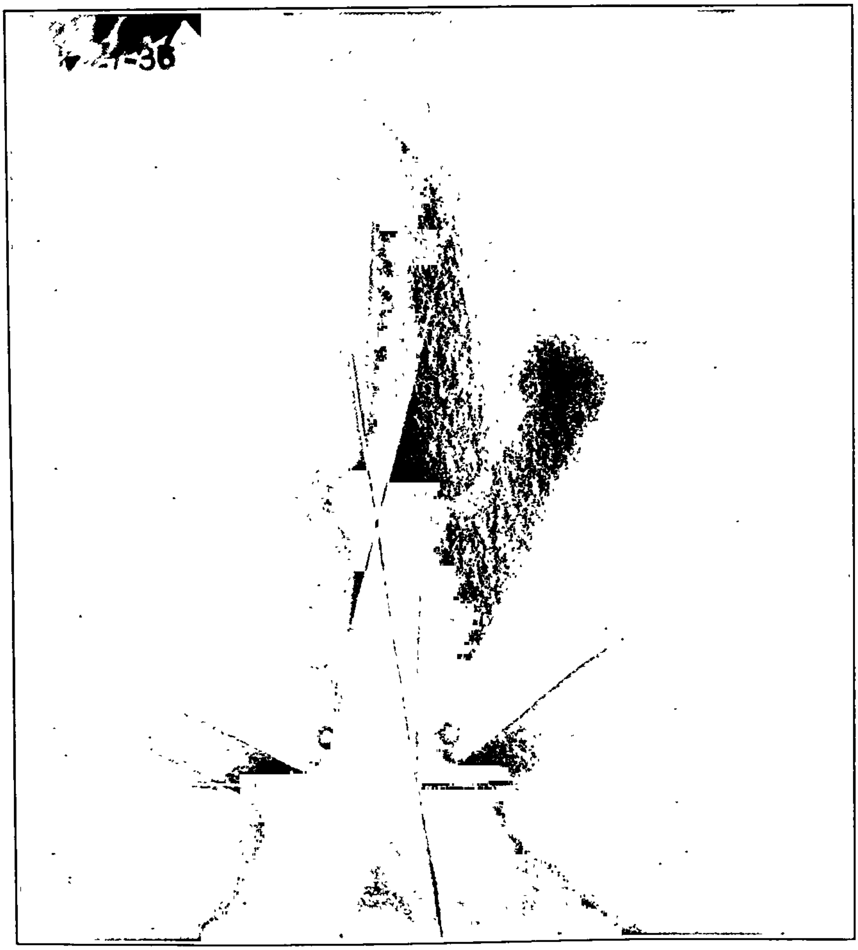

Fig. 10

Case 2. Roentgenogram taken with the patient in the standing position and with the brace on. The lower curve is corrected slightly; the dorsal curve is corrected markedly. Note the increased width of the intercostal spaces on the left side.

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A SIMPLE METHOD FOR THE AMBULATORY CORRECTION OF FLEXION CONTRACTURE OF THE KNEE

THE USE OF CONTINUOUS ELASTIC TENSION AS THE CORRECTIVE FORCE *

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The author begs indulgence for the addition of still another specimen to the array of apparatus designed for the correction of flexion deformity of the knee, secondary to soft-tissue contracture. The principle of continuous elastic tension is utilized as the corrective force. This continuously active tensile force appears to be more truly the reverse of the mechanism of contracture of the muscular and capsular structures causing the deformity than does the jerky stretch-and-hold principle employed by turnbuckle or ratchet. Especially gratifying is the absence of persistent discomfort, requiring the habitual use of analgesic or soporific drugs, which so constantly accompanies correction by the more rigid mechanisms.

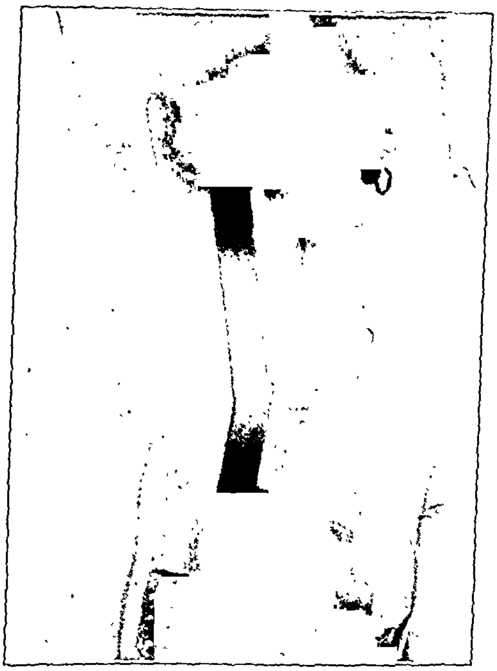

FIG. 1

FIG. 2

Fig. 1: Lateral roentgenogram of the knee and apparatus showing the amount of extension obtained before weight-bearing is allowed.

Fig. 2: Lateral roentgenogram taken following Figure 1. The patient is actively flexing the knee against the corrective tension, thus indicating the range of motion allowed by the apparatus. The elastic bands are not radio-opaque and, therefore, are not visualized.

* From the Lenox Hill Hospital, Department of Orthopaedic Surgery, Service of Charles H. Jaeger, M.D.

The amount of elastic tension needed for rapid extension does not prevent the patient from actively flexing the knee through the range of previous correction (Figs. 1 and 2). The fear of limitation of motion in extension, due to the organization of intra-articular effusions in the subacute and actively chronic arthritides, is thus banished. The healthy impetus imparted to muscular and capsular physiology by active joint motion avoids the extended periods of physiotherapy required subsequent to correction by the less elastic systems.

The malleoli and the infrapatellar, suprapatellar, and lower gluteal regions are protected against undue pressure by felt pads, and a circular plaster-of-Paris casing is snugly molded over stockinet from the toes to the groin. The casing is divided by the removal of a wedge of plaster, tapering posteriorly, from over the knee. The thigh and leg plaster cuffs thus formed are then articulated by two swivel hinges incorporated into their lateral aspects. Two pairs of small cup hooks are screwed into the anterior aspects of each cuff, and long, thin rubber bands are then suspended from them so as to cross the joint. (See Figures 3 and 4.) The patient is returned to bed, and the leg cuff is suspended in a canvas sling

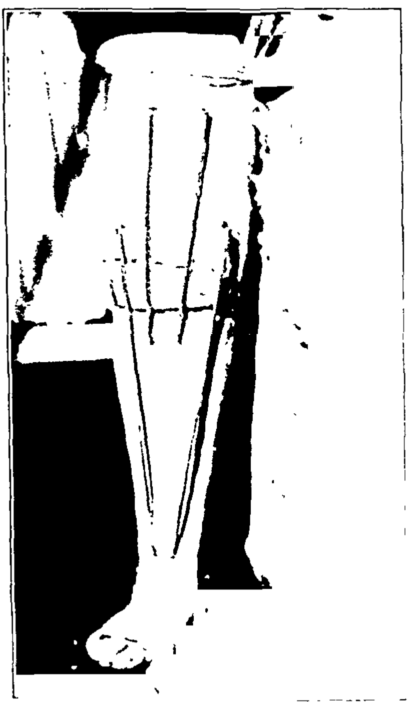

FIG. 3

FIG. 4

Fig. 3: Patient ambulatory. Front view. The arrangement of the cup hooks and elastic bands is clearly depicted.

Fig. 4: Patient ambulatory. Side view. Note the edges of the three protective felt pads and the position of the incorporated hinge. The heel and malleoli are generously exposed to avoid friction and pressure at those points.

so weighted as to counterbalance its inertia and thus allow the elastic tension to operate solely upon the contracture. One or two bands are added daily to each series of hooks.

After a short period of recumbent correction, enough extension is obtained to enable the patient to walk in his apparatus with the aid of crutches. This is managed quite easily, for the knee enjoys an excursion of from 15 to 20 degrees with each step. Hospitalization is thus terminated at a relatively early date, and the progress of the case is followed from the Out-Patient Department. Another decided advantage of this method over those previously employed is that it avoids the use of any retentive postcorrective brace or cast, for the primary corrective apparatus may be used in such capacity for as long a time as the surgeon deems necessary.

No originality is claimed by the author for the employment of continuous elastic tension in the treatment of flexion contracture of the knee. It is desired merely to present a simple apparatus, embracing this principle, which has proved successful in his hands.

The writer wishes to thank Dr. Charles H. Jaeger for the opportunity of developing this method in the treatment of cases upon his Service, Dr. Walter I. Galland for his suggestions and encouragement, and Dr. Raymond Gettinger for his kindness in taking the photographs used as illustrations.

BENIGN GIANT-CELL TUMOR OF THE FOURTH LUMBAR VERTEBRA

A Case Report

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The occurrence of giant-cell tumor involving the vertebral arch and body is so unusual and the methods of treatment have been so varied that it seems worth while to add the following case to the fifty which have been reported in the literature. The treatments employed have included atoxyl, Coley's serum, roentgen ray, radium, and partial or complete surgical removal. In one case bone chips were placed in the cavity. Our patient was treated as in the last instance, but spine fusion was also done to prevent the vertebral collapse and cord-pressure symptoms which have frequently resulted in the reported cases. The result obtained was cure of the tumor and complete relief of symptoms.

CASE REPORT

An Italian girl, aged seven, was admitted to the New York Orthopaedic Dispensary and Hospital on October 21, 1927. She had had pain in the region of the left hip for four months. There was no known injury or illness associated with the onset. The pain had increased in severity, but no limp had been noticed by the child or by her parents. She attended school regularly and ran about quite freely. Occasionally she was forced to sit down and rest because of slight pain in her back. She slept well without night cries and was most comfortable lying on her back. Her appetite was poor. She had no cough, hemoptysis, or night sweats. Her father had active pulmonary tuberculosis at this time.

Physical Examination

The child was well developed and nourished. The examination was essentially negative except as follows:

Abdomen: The left lower quadrant was quite tender on palpation and felt fuller than the right side.

Spine: A small kyphos was present at the first lumbar vertebra. Tenderness was present at the spine of this vertebra, but was greater over the lower lumbar spines. The entire lumbar spine was held rigidly and all motions were limited 50 per cent. by pain or spasm.

Left Lower Extremity: There was atrophy of the thigh amounting to one-half an inch. No paralysis was found. The anterior and lateral aspects of the hip were slightly tender, but all motions of the hip were free except straight-leg raising, which caused considerable pain in the region of the lumbar spine.

The Mantoux test was positive, but other routine laboratory examinations were essentially negative.

Roentgenographic Examination

A roentgenogram taken on October 21, 1927 (Fig. 1) showed the entire left transverse process of the fourth lumbar vertebra to be expanded to more than three times its normal diameter. Cortex was present over the whole mass, but was thinned almost to the point of invisibility. No trabeculae were visible within the tumor, although a few dense lines were present which apparently represented ridges in the cortex. The lesion extended into the pedicle and thence slightly into the body of the vertebra. The left psoas muscle was prominent opposite the mass. The intervertebral discs were not affected. The bone shadows were clear and there was no obscuring of detail as would be apparent if the lesion were purulent. At this time it was thought that the lesion might be an enchondroma.

On February 1, 1928 the lesion had increased in size and had extended into the lamina and body (Fig. 2). Most of the left half of the vertebral body was then involved. The third lumbar vertebra was slightly displaced to the left on the fourth vertebra and was tilted in the same direction. It was thought that the rapid increase in size of the lesion was due to hemorrhage within it, but this was not substantiated at operation.

Treatment

The patient entered the hospital on March 6, 1928. Her symptoms had abated considerably, but the rapid progress of the tumor seemed to indicate the necessity of

Fig. 1

October 21, 1927. Before operation. Showing involvement of the entire left transverse process and a small portion of the pedicle and body of the vertebra.

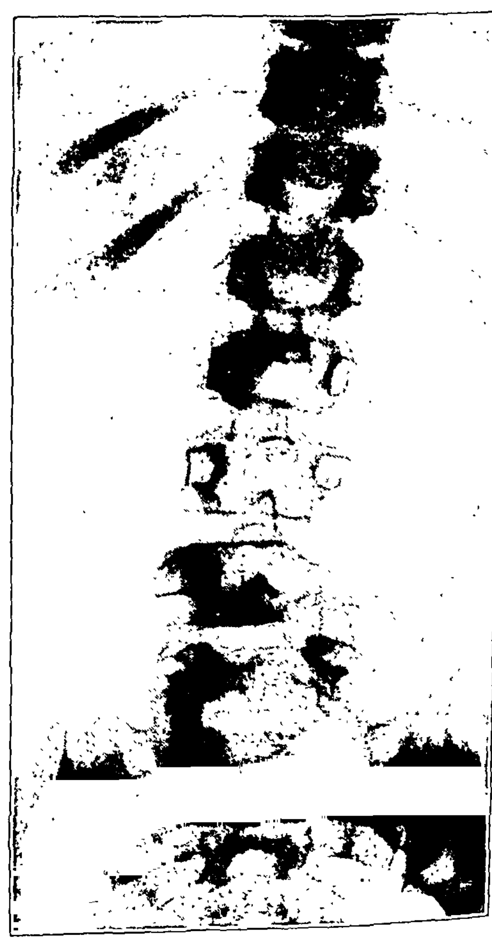

Fig. 2

February 1, 1928. Before operation. Showing increase in the size and extent of the lesion.

FIG. 3-A

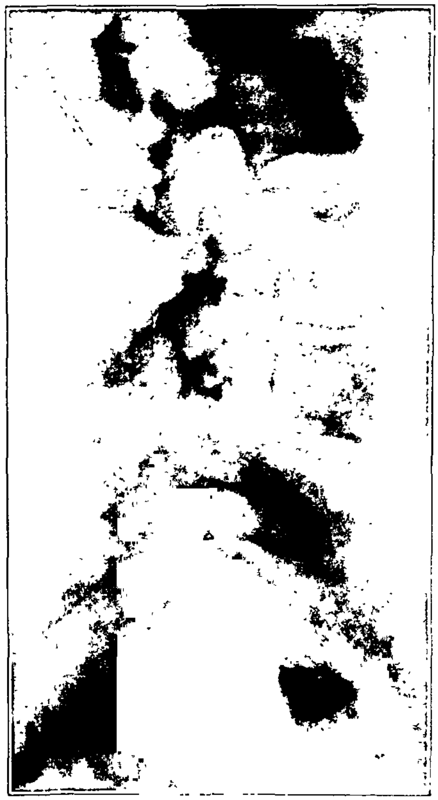

FIG. 3-B

January 14, 1933. *After operation.* Anteroposterior and lateral views, showing solid spine fusion and no evidence of recurrence of the tumor.

immediate treatment. Roentgen-ray therapy seemed inadvisable in view of the proximity of the lesion to the kidneys and pelvic organs. Exploration of the tumor was undertaken on March 28, 1928 by Dr. H. L. von Lackum.

Operative Procedure

Through a longitudinal incision adjacent to the midline, the arches of the vertebrae from the second lumbar to the first sacral were exposed by subperiosteal dissection. The left side of the fourth lumbar arch was blanched and somewhat eroded. In dissecting laterally over the transverse process, the bone shell was broken and the tumor mass appeared. It bled only moderately, was enclosed in a complete bone shell as large as a walnut, and had the appearance of tuberculous material. The contents of the shell were removed and the involved portion of the vertebral body was curetted through the pedicle. Bone shavings from the posterior aspect of the ilium were packed into the cavity in the body, pedicle, and transverse process. Fusion of the third and fourth lumbar vertebrae was performed according to the technique of Hibbs.

Pathological Report

The material consisted of fairly cellular fibrous tissue, containing many giant cells and some bone trabeculae which were undergoing absorption and destruction. Several areas of leukocytic (mostly lymphocytic) infiltration were seen. An occasional mitotic figure was noted, but no osteoid tissue.

The diagnosis was giant-cell tumor.

Subsequent Course

The patient remained in bed with a metal brace adjusted to her back. On July 31, 1928, roentgenograms revealed that new bone was developing about the chips in the cavity, and fusion of the third and fourth lumbar vertebrae appeared firm. There was no evidence of further bone destruction at this time, but some portions of the cavity in the lamina were not occupied by bone shavings.

On November 26, 1928, by means of the Hibbs technique, the spine fusion was extended from the fourth lumbar vertebra to the sacrum. It was thought that this fusion would eliminate the possibility of fracture or collapse of the vertebrae. At the same time the small remaining defect in the lamina was filled with bone shavings.

The patient was allowed up on April 10, 1929, and she was discharged from the hospital two weeks later.

The patient was last seen in January 1933, at which time she was feeling perfectly well. She denied any pain, ache, or fatigue in her back. She was quite active and had no disability. She could walk several miles easily. The fusion of the spine was solid. There was no tenderness or spasm. Motion above the fusion area was free. Were it not for the incisional scars it would be difficult to tell that there had ever been anything wrong with her back.

Roentgenograms (Figs. 3-A and 3-B), taken on January 14, 1933, revealed a solid spine fusion from the third lumbar vertebra to the sacrum. There was no evidence of recurrence of the tumor. The bone structure in the previously affected area appeared more normal than formerly.

INTRATARSAL DISLOCATION

Report of a Case of Anterior Midtarsal Dislocation

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The case here reported is one which we term anterior midtarsal dislocation in contradistinction to the classical midtarsal dislocation. It is a dislocation in which the scaphoid remained in its normal relation to the astragalus and os calcis, while the remaining tarsals and metatarsals were dislocated as a unit. A search of the records of the hospitals with which we are associated revealed no other such dislocation. A review of the literature also failed to show a similar case. We could find no text-book or dictionary in which this type of injury was described. It is felt, therefore, that the case is sufficiently rare to warrant its inclusion in the literature.

A. T., a negro stevedore, aged forty-five, was injured on December 15, 1930, when a heavy, horse-drawn truck backed onto his right foot. He was crouched down in such a position that the force of the wheel was applied to the medial and plantar surface of his foot. He was unable to walk and was carried to his home.

Four hours later he was admitted to the Reconstruction Hospital. Local examination showed marked swelling of the right foot with an extremely tight figure-of-S bandage about it and the ankle. Over each malleolus there was a swelling about the size of an orange. When the bandage was removed marked bony deformity of the foot was noted. The forefoot was displaced laterally and slightly backward. On the medial border, a distinct bony outline could be felt, which appeared to be the scaphoid in its normal contact with the astragalus. The cuboid could be felt in an abnormal position on the lateral border of the foot. The impression was that the scaphoid and metatarsals were in their normal relative positions. Roentgenographic examination (Fig. 1) showed a complete lateral and backward displacement of the distal row of tarsals.

Fig. 1

Roentgenogram showing anterior midtarsal dislocation. Fracture of the cuneiform is also evident.

One hour after admission, under spinal anaesthesia, closed manual reduction was attempted with some improvement. The swelling of the part was now marked. The patient was put to bed with the leg elevated in an attempt to bring down the swelling. On the following

day, again under spinal anaesthesia, further manual manipulation was attempted with no improvement. The Moorhead repositor with 100 pounds of traction on the forefoot also failed to accomplish the desired result. On December 17, 1930, again under spinal anaesthesia, repositor reduction was once more attempted without success. Two attempts at manual and two attempts at repositor reduction had been unsuccessful.

After four days, during which the leg was elevated and wet dressings were applied, the swelling and inflammatory reaction had subsided to a marked degree. A Steinmann pin was inserted through the metatarsals and another through the os calcis. The knee was then flexed to an angle of 135 degrees and the patient was put to bed. Six and one-half pounds of traction was applied to the posterior pin and eleven and one-half pounds to the anterior pin (Fig. 2).

Twenty-four hours later, examination showed a rather marked improvement in the condition of the foot. The swelling had receded and the anatomical alignment seemed perfect. Roentgenograms were made with the nails in place (Fig. 3) and showed an almost complete reduction.

On January 16, 1931 the swelling had entirely receded and a plaster-of-Paris casing was applied, incorporating the nails. Roentgenograms verified the excellent reposition of the parts. On January 19, 1931 the nails were removed without anaesthesia. The plaster-of-Paris casing was not disturbed and roentgenograms taken immediately showed the position to be maintained. It is worthy of note that a fracture had occurred through the head of the fourth metatarsal at the point of transfixion.

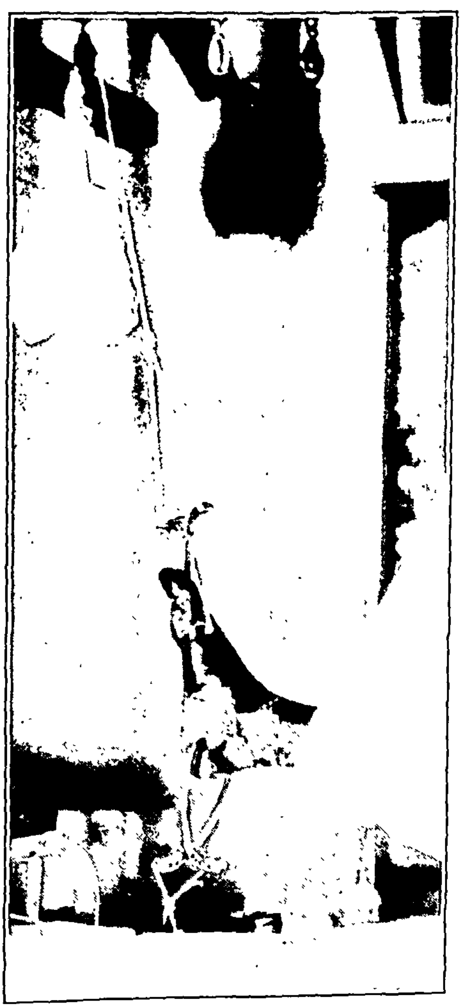

Fig. 2

Showing Steinmann pins in place and traction and countertraction applied.

On February 19, 1931 the plaster casing was removed and the part was inspected. It was deemed advisable to continue immobilization with the ankle placed in dorsiflexion at an angle of 80 degrees. The foot was kept in midposition throughout treatment and was neither everted nor inverted. A plaster casing with walking iron was applied.

On March 25, 1931 this casing was removed. Motion of the ankle was from 110 to 130 degrees. Moderate inversion and eversion of the foot were possible. Flexion of the toes was present, but extension was lost. Roentgenographic examination showed that the reduction was maintained. The fracture through the head of the fourth metatarsal was firmly united and the fragments were in good position. Periarticular disuse atrophy was noted in the bones of the ankle and foot.

On March 29, 1931 the patient complained of pain in his foot and a plaster-of-Paris casing with walking iron was again applied. The casing was removed on April 16, 1931. Active motion of the ankle was noted from 90 to 110 degrees; extension of the toes was still lacking. A combination Whitman foot plate was ordered and applied on April 25, 1931. On June 4, 1931 motion of the ankle was found equal to that of its mate. Alignment of the bones was good. The fracture of the fourth metatarsal was firmly united. On July 25, 1931 all motion was normal, with the exception of the great toe.

FIG. 3
Roentgenograms of foot showing the pins in place and the reduction obtained.

FIG. 4
Roentgenograms taken at the time of discharge.

Follow-up examination on September 20, 1932 showed that the patient walked without a limp. He could walk on his heels or on his toes. He hopped about the room on the affected foot without difficulty. He was able to climb stairs and to climb the rungs of a ladder. He had no brace and no plate in his shoe. The foot appeared normal except for bony thickening over the scaphoid. On November 5, 1932 he was discharged as cured.

SUMMARY

This patient exhibited a complete anterior midtarsal dislocation without abrasion or laceration of the skin. The distal tarsus was dislocated laterally. Manipulative reduction was attempted four times without success. Reduction by skeletal traction and countertraction was successful and the end result is a practically complete functional restoration of the foot.

BILATERAL RECURRENT DISLOCATION OF THE ULNA AT THE ELBOW

BY HENRY MILCH, M.D., F.A.C.S., NEW YORK, N. Y.

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As far as can be discovered, the following case is unique in the world's literature. No one with whom the author has spoken has ever seen or heard of a similar case. It is interesting to note that one other case of recurring luxation of the ulna at the elbow has been recently described by Sorrel [1]. It appears, however, that Sorrel's case was unilateral and apparently traumatic in origin. The case herewith reported is bilateral and congenital in nature.

W. S., male (Hospital No. 56720, Out-Patient Department No. B 19534), was first seen in the Out-Patient Department of the Hospital for Joint Diseases at the age of eight on November 29, 1926. It was stated that the first dislocation of the elbow had occurred at the age of fourteen months. He had had no trouble from that time until he was seven years old, when he fell and again dislocated the elbow. In October 1926, following another fall, he suffered a supracondylar fracture of the right humerus, which had been treated at a city hospital before the patient came to the Hospital for Joint Diseases. The convalescence was uneventful.

In February 1930, the patient again fell and the roentgenogram was reported as showing a slight posterior dislocation of the right elbow. This was reduced and the patient remained well until the following September, when another dislocation developed, following another fall. (See Figure 1.) At this time it was first noted that the semilunar notch (greater sigmoid cavity was definitely flatter and shallower than normal. The dislocation was reduced. Since that time the patient has had repeated dislocations, — the right elbow, five times and the left elbow, four times. On December 20, 1935, at the age of seventeen,

FIG. 1

Roentgenogram, taken September 29, 1930, showing posterior dislocation of the right ulna. Note the almost straight line of the semilunar notch.

* From the Service of Harry Finkelstein, M.D.

the patient again appeared in the Clinic with the statement that he had dislocated the right elbow while tying his shoe lace the previous night. A roentgenogram (Fig. 2), which was taken immediately, showed no evidence of dislocation.

Although the dislocation had apparently been reduced spontaneously, it was observed that the shallowness of the semilunar notch previously noted still persisted. When compared with that of a relatively normal elbow of a child of the same age, it was found that the semilunar notch of the normal child, from the tip of the olecranon to the tip of the coronoid, measured approximately one and seven-sixteenths inches in length and subtended a central angle of 122 degrees in a circle with a radius of eleven-sixteenths of an inch, while the semilunar notch of this patient measured one and seven-sixteenths inches and subtended an angle of 94 degrees in a circle with a radius of fourteen-sixteenths of an inch. The difference in the degree of convexity can be readily gauged from these figures and is graphically shown in Figure 3 which represents the arcs of the two semilunar notches as traced from the roentgenograms.

It was felt that this represented a true deviation from the normal and was the possible cause of the recurrent dislocations. With this idea in view, the patient was admitted to the hospital for the purpose of performing a bone-block operation at the tip of the coronoid process, so as to prevent future dislocations. Examination disclosed no limitation of motion or abnormality of motion at the elbow. The carrying angles of both arms were obliterated. All the laboratory examinations were essentially normal.

Operation was performed on January 9, 1936 under general anaesthesia. A four-inch incision was made on the anteromedial aspect of the right elbow, directly over the course of the brachial artery. The median basilic vein was then tied and the bicipital lacertus fibrosus was incised. This permitted a view of the medial border of the biceps brachii which was retracted laterally along with the brachial artery and vein. The median nerve was next identified and retracted medially. This exposed the longitudinal fibers of the brachialis anticus at the bottom of the wound. These were split in a longitudinal direction, exposing the capsule which was opened longitudinally directly over the blunted tip of the coronoid process. A quarter-inch drill hole was then made in the ulna, beginning at the tip of the coronoid process and extending obliquely backward and downward into

FIG. 2

Roentgenograms of both elbows at time of admission to the hospital in December 1935. Note that the line of the semilunar notch is still only very shallow.

the body of the ulna. The wound was then temporarily closed while a boomerang-shaped bone graft about one and one-half inches long was removed from the anterior ridge of the tibia. This was carefully placed into the coronoid hole previously prepared, so that the beak of the graft pointed upward as if continuing the curve of the semilunar notch. This extended and enlarged the notch. With this fragment *in situ*, it was possible to completely flex the elbow, the graft apparently entering the coronoid fossa. The capsule was then closed behind the graft, the longitudinal fibers of the brachialis anticus were

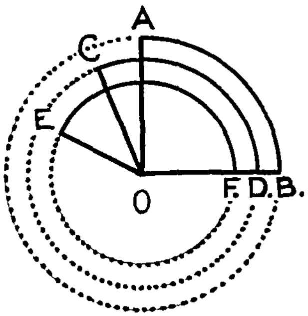

FIG. 3

Concentric circles showing graphically the radius of curvature, the actual length of the arc, and the angle subtended on the x-ray by the normal and abnormal and reconstructed semilunar notches.

$AB = CD = \frac{23}{16}$ in.
$OC = \frac{11}{16}$ in.
$OA = \frac{14}{16}$ in.
Angle $AOB = 94°$
Angle $COD = 122°$
Angle $EOF = 159°$
$OE = \frac{19}{32}$ in.
$EF = \frac{25}{16}$ in.

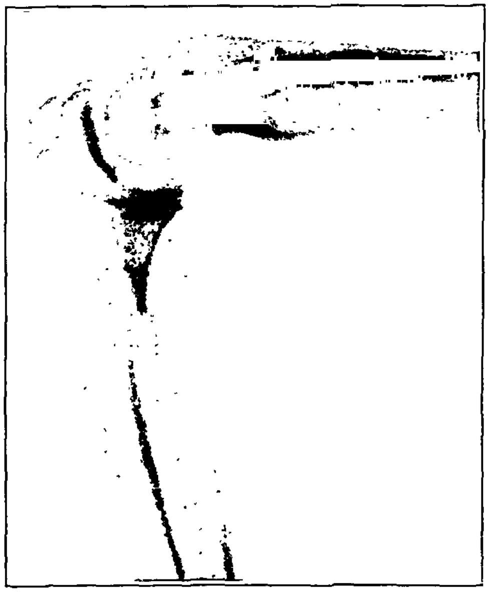

FIG. 4-A

X-ray showing the bone graft *in situ*. Note increase in the convexity, as well as in the length of the semilunar notch, as compared with the preoperative x-ray. (See Figure 2.)

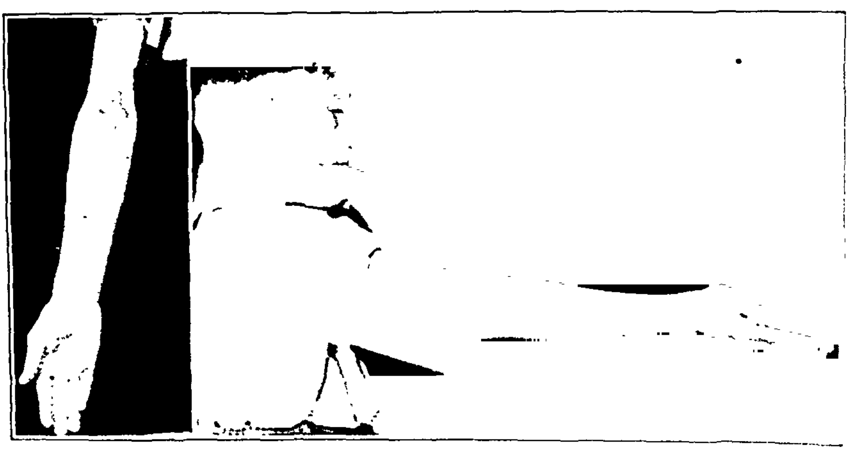

FIG. 4-B FIG. 4 C

Showing extent of flexion and extension in March 1936

sutured in front of the graft, and the skin was closed with silk. A plaster-of-Paris bandage was applied with the elbow in flexion for a period of two weeks, after which all dressings were removed. After the bandage was removed, the arm was allowed to hang down, so that gravity tended to restore complete extension. By the middle of March, all motions had returned to normal except for slight limitation of extension (Figs. 4-B and 4-C). The roentgenogram (Fig. 4-A) showed "a well formed bone peg, well placed in the coronoid process and enlarging the extent of the sigmoid cavity". By actual measurement of the x-ray tracing it was found that the new semilunar notch measured one and nine-sixteenths inches and subtended an arc of 159 degrees in a circle with a radius of nineteen thirty-seconds of an inch. When the patient was last seen at the end of five months, there was still no evidence of any recurrence. The case is reported more for the unusual nature of the condition than for the certainty of the satisfactory operative result. The left elbow will be operated upon as soon as symptoms of dislocation appear.

The mechanical problem presented by this case lent itself to a number of theoretical solutions. First, it would have been possible to reef or to reenforce the collateral ligaments; but the experience gained in capsuloplastics in other dislocations was such as not to make this prospect too alluring. Secondly, the possibility of modifying the convexity of the sigmoid notch by performing a juxta-articular osteotomy was considered. This, too, was discarded when it was realized that success might involve a serious disturbance in the radial notch and, therefore, in the motion of pronation and supination of the forearm. There remained, finally, the possibility of bone block. Sorrel was apparently successful in preventing dislocation by raising an oblique buttress parallel to the lower and outer rim of the olecranon fossa. The principle which guided Sorrel was the prevention of the outward gliding which was secondary to a presumed relaxation of the ulnar collateral ligament. In our case there appeared to be a definite congenital malformation of the semilunar notch and the indication was definitely to correct this. Two methods of accomplishing this were considered,—one, a bone graft into the coronoid fossa, and the other, osteotomy and forward flexion of the tip of the olecranon process, so as to prevent complete extension. The former of the two methods was chosen. Whether or not the result will be permanent only time can tell.

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EXTENSION DEFORMITIES OF THE PROXIMAL INTERPHALANGEAL JOINTS OF THE FINGERS.

An Anatomical Study

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The object of this paper is to show the results of a few experimental observations made on cadavera with the purpose of explaining the mechanism of the often observed hyperextension deformities of the proximal interphalangeal joints of the fingers.

As is well known, an investigation of this sort, connected with muscle activities, cannot be considered complete unless at least three known methods of study are used. The anatomical method, the first employed historically, should perhaps be followed by the electrical method, introduced by Duchenne, and by the physiological method. This last, based on the study of normal muscular contractions in normal living subjects and in spastic and paralytic patients, completes the description of muscle action and corresponding motion of the joints. Thus, the limitations that such a study involves are well recognized.

The following two cases stimulated the present investigation:

Case 1. H. W., a male, fifty-six years old, who presented a bilateral Dupuytren's contraction involving the fourth finger only, accidently struck the distal phalanx of the fourth finger of the right hand against an obstacle. After the accident the patient noticed that the tip of this finger remained flexed. The patient, who is a chauffeur, did not have much trouble with the Dupuytren's deformity. However, the finger-tip drop was definitely troublesome, and this prompted him to seek medical advice.

At operation, through an inverted L incision, the palmar fascia was removed. The torn extensor tendon at the distal interphalangeal joint was sutured through a dorsal incision over the fourth finger. After the operation a palmar splint was applied, which held all three phalanges of the fourth finger in extension. Subsequently a very small slough developed at the corner of the incision, but this healed rapidly.

Several weeks later it was noticed that the flexion of the distal phalanx of the fourth finger had recurred. At this time it was found that there were no adhesions between the skin and the tendon sheath of the fourth finger; thus, Dupuytren's contraction was apparently eliminated. The proximal interphalangeal joint of the fourth finger was kept hyperextended and the distal phalanx slightly flexed. The metacarpophalangeal joint was maintained in very slight flexion. The interossei of the fourth finger were functioning perfectly. Apparently the lumbricales were also functioning very well. Lateral motion of the fourth finger was excellent and active flexion at the metacarpophalangeal joint was normal. The fourth finger, when flexed at the metacarpophalangeal joint, was kept hyperextended at the proximal interphalangeal joint until the angle of flexion at the metacarpo-interphalangeal joint reached 90 degrees; then the proximal interphalangeal joint started to flex and only then did it flex normally with the other fingers, although further down it lagged again and could not be flexed completely to make a fist. When the flexed fingers were extended from the position of a fist, it could be noticed that the two distal phalanges of the fourth finger were extending very much faster than the prox-

* Service of Harry Finkelstein, M. D.

imal phalanx of this finger. The proximal phalanges of the *other fingers were already* extending while the proximal phalanx of the fourth finger was *still resting. At further extension*, the two distal phalanges were more extended than the proximal phalanx, and a marked hyperextension at the proximal interphalangeal joint was then noticed. This angle was maintained up to the limit of extension of the finger at the metacarpophalangeal joint.

CASE 2. N. N., a male, eighteen years old, had sustained an injury to the right middle finger while playing baseball. The ball had hit the volar surface of the distal part of this finger and acute pain had followed. The patient was treated for the pain and for a gradual disability which developed subsequently and which consisted in an inability to *flex the finger at the proximal interphalangeal joint after full extension* of the three phalanges.

The patient came for examination nine months after the original injury. He had a marked hypotonia of most of the joints, *especially noticeable in the smaller joints* of the hand. The injured finger could be passively hyperextended to about 205 degrees at the proximal interphalangeal joint. This finger could be actively hyperextended to about 190 degrees at the same joint. After full voluntary hyperextension of the finger, an attempt to flex all of the fingers (to make a fist) resulted in normal flexion in all of the fingers except the *middle one, which remained hyperextended at the proximal interphalangeal joint*. The distal phalanx of this finger was the only one that flexed almost to 100 degrees. Two distinct lateral cords of the collateral extensor tendon of the finger could be seen to be very tense under the skin of the dorsal aspect of the finger. No matter how hard the patient tried to flex this finger it would remain hyperextended at the *proximal interphalangeal joint. This injury interfered very much* with the activities of the boy. Lateral motion of this finger and of the other fingers was normal.

There was evident a certain similarity in these two cases. In order to find an explanation of the mechanism of this interphalangeal deformity, this study has been undertaken. The problem was to identify the structure, the injury of which was responsible for the deformity, and to reproduce if possible the condition which has been described. The results were as follows:

A cadaver of a female, twenty-four years old, was first examined. The hands did not show any abnormalities. The fingers could be flexed and extended normally. The third, fourth, and fifth fingers of the right hand were chosen for the investigation. Two small incisions were made on the lateral and medial sides of the fifth finger; the proximal interphalangeal joint was approached; and the tendon sheath, together with the tendons, was completely separated from the anterior capsule of this joint. With a pointed knife, the anterior ligament of the capsule was cut, and an attempt to hyperextend the proximal interphalangeal joint produced a very slight hyperextension. The tendon of the flexor sublimis was then cut, and the hyperextension was slightly increased. The same procedure was repeated on the fourth finger, but both tendons, the flexor sublimis and the flexor profundus, were cut across. Even then, however, there was only very slight hyperextension. On the third finger, the collateral ligaments of the finger, in addition to the anterior ligament, were cut, leaving the flexors intact. In this case a marked hyperextension followed at the interphalangeal joint.

The second observation was made on a male cadaver, thirty-five years old, with normal hands. Two lateral skin incisions were made through which the capsule and collateral ligament of the proximal interphalangeal

joints were approached and cut across. The tendons were left intact and a slight hyperextension could then be produced manually. The extensor digitorum communis tendon was exposed on the dorsum of the finger. A pull on this tendon produced extension of the first phalanx only. The tendons of the lumbricales and interossei were then exposed. A pull on the lumbricales produced hyperextension of the proximal interphalangeal joint without radial deviation. Although the pull was produced on one lumbricalis only, two distinct cords, equally tense and corresponding to the expansion of the extensor digitorum communis tendon, could be observed under the skin of the dorsum of the finger. From the interphalangeal joint up to the distal phalanx, the pull on the tendons of the interossei produced almost equal tension of the above mentioned cords with similar hyperextension. The tendon of the flexor sublimis was cut across the line of the interphalangeal joint of the same finger. This was followed by considerable hyperextension, which could be obtained by bending the finger at this level. The same amount of hyperextension was obtained by pulling the lumbricalis tendon. There was no radial deviation of the finger and again the two tendon cords could be seen on the dorsum of the finger. The pull on the interossei tendons produced almost equal hyperextension at the proximal interphalangeal joints and normal extension of the distal phalanx. Next, the capsule was left intact and the tendon of the flexor sublimis only was cut across the joint. The result of this experiment, made through two lateral skin incisions, was very much less pronounced than in the previous experiment when the capsule also was cut.

With the lumbricales, interossei, extensor digitorum communis, and flexor digitorum tendons exposed, a deformity similar to the one observed on the patients could be easily reproduced in the following fashion: The anterior capsule, the collateral ligaments of the interphalangeal joint, and the bifurcation of the sublimis tendon were found lying across the joint line; the pull on the lumbricales fixed the proximal phalanx in extension, and, at the same time, the pull on the flexor digitorum profundus produced a hyperextension at the proximal interphalangeal joint and a flexion of the distal phalanx of the finger.

Repair of the anterior capsule, including the collateral ligaments, which produced a very slight flexion of the proximal interphalangeal joint, was sufficient to prevent the deformity, in spite of the fact that the cut sublimis tendon was left unrepaired.

Thus, it appears that a reconstruction of the anterior capsule and of the collateral ligaments of the proximal interphalangeal joint, which produces a slight flexion to restrict the angle of action of the lumbricales and interossei, could produce a satisfactory elimination of the hyperextensive activity of these muscles at the proximal interphalangeal joint. This procedure would not eliminate the normal abductor, adductor, and partial-extension activity of the interossei and lumbricales; neither would it eliminate the flexor action of these muscles on the first phalanx. Better functional results could perhaps be expected subsequently.

A THREE-POINT HYPEREXTENSION BACK BRACE

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Considerable experience in the ambulatory treatment of compression fracture of the spine by the method of Watson Jones[1] has recently led the author to the conclusion that an efficient adjustable hyperextension back brace might be of value in such cases. Such a brace should supply and hold any desired degree of hyperextension, should avoid the discomfort and hygienic disadvantages of a plaster jacket when worn for three or more months, and should not deteriorate during the period of use.

The purpose of hyperextension is to bend the deformed spine, so that the abnormal angulation at the point of kyphosis is corrected. The most efficient mechanical means of bending a rod or column is to place a fulcrum at the point of desired angulation and to apply counterpressure at both ends of the column. No other points of contact are necessary. In the conventional type of back brace, a fulcrum is formed by full-length rigid posterior bars. Counterpressure is applied around the pelvis by straps attached to the lower ends of the bars and around the chest and shoulders by straps from the upper ends of the bars. The straps around the chest are relatively ineffective because of the wide range of respiratory movement. Pressure applied to the soft parts of the shoulders must be transmitted through the clavicles to the sternum, thence to the upper ribs, and finally to the spine. The instability of the mobile shoulder girdle greatly reduces the efficiency of this complicated transfer of force, so that only partial immobilization of the spine is obtained.

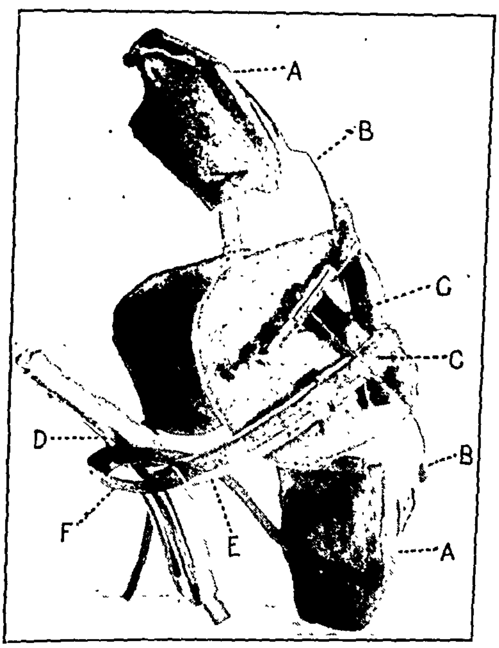

Fig. 1

Showing the details of the brace: the anterior pressure pads (*A*); the hyperextension bars (*B*) which pivot at the swivel joints (*C*); the posterior fulcrum (*D*) which is adjusted by the removable yoke (*E*) and straps (*F*); and the hyperextension screw (*G*) which forces the plates (*A*) backward.

The brace illustrated was developed in an attempt to apply mechanically effective counterpressure to the spine at both ends of the trunk against a posterior fulcrum at the peak of the kyphos. Backward pressure is applied to the lower end of the spine from the symphysis pubis directly through the pelvis to the sacrum. At the upper end, pressure

is transferred by the most direct bony route, through the manubrium and short upper ribs to the superior thoracic spine. Hyperextension is positive and may be increased slowly or rapidly to any desired degree. Only the three essential points of contact are utilized. Long posterior bars and encircling straps are not necessary. This results in the minimum of interference with thoracic and abdominal movement and makes most of the trunk accessible. The small forward excursion of the first two or three ribs causes little reduction in efficiency.

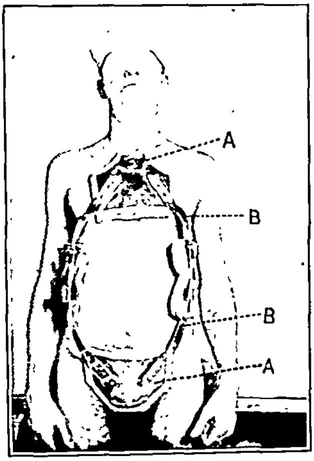

FIG. 2

Anterior view, showing anterior plates (*A*, *A*) and bars (*B*, *B*).

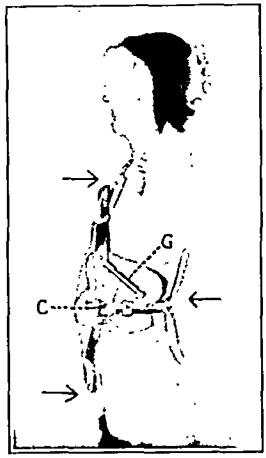

FIG. 3

Lateral view, showing force exerted at the three essential points.

Over the symphysis pubis and upper sternum are padded, form-fitting stainless-steel plates (Figs. 1, *A* and 2, *A*). Hinged to each of these plates are steel bars (Figs. 1, *B* and 2, *B*) which curve to swivel joints (Figs. 1, *C* and 3, *C*) at the sides of the trunk. These bars are adjustable in length, so that the joint may be raised or lowered to a point opposite the kyphos and in order that the brace may be adjustable enough to fit patients within a reasonable range of size. The posterior fulcrum (Figs. 1, *D* and 4, *D*) is a curved rectangular steel or aluminum-alloy plate, the center of which is cut out over the spinous processes. The fulcrum is attached to and adjustable upon a steel or aluminum-alloy yoke (Figs. 1, *E* and 4, *E*), the ends of which run through slots at the joints. By means of this yoke and the straps (Fig. 1, *F*) the fulcrum may be moved forward or backward in relation to the joint and the anterior plates. With the fulcrum fixed in relation to the joints, the anterior plates may be moved backward by the screw (Figs. 1, *G* and 3, *G*), which changes the angle between the side bars to an alignment more nearly parallel to the longitudinal line of the body.

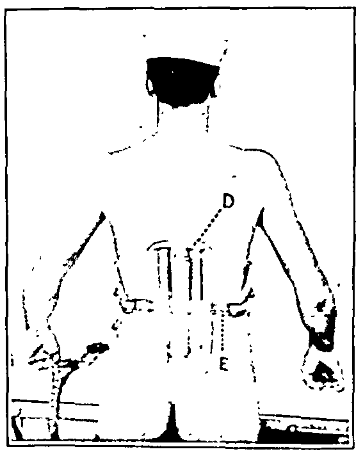

FIG. 4

Posterior view. The fulcrum plate (*D*) is open in the center to prevent pressure on the spinous processes. It is movable up and down on the yoke (*E*).

The brace is applied with the screw released. The fulcrum is first adjusted as snugly as possible by means of the yoke and straps. The screws are then tightened until the proper position is obtained. The firm, powerful, yet comfortable hyperextension which may be obtained with this brace can best be appreciated by comparing it with that secured with the conventional type of brace. While this appliance was designed for the convalescent support of compression fractures of the lumbar and lower dorsal spine, it is hoped that it will prove useful in other conditions in which positive controlled hyperextension is desired.

The author is indebted to Mr. A. C. Wilde to whom is due a great deal of credit for working out the mechanical details of the brace and for numerous improvements on the original idea.

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A METHOD OF IMMOBILIZING THE CHEST

BY ADOLPH M. BROWN, M.D., CHICAGO, ILLINOIS

Recent innovations in methods used to immobilize the chest indicate the effort to provide greater comfort, and the growing conviction that not two-thirds, but the entire chest must be strapped to obtain adequate immobilization. The method here offered was first used for a fractured sternum. The procedure proved surprisingly comfortable and effective and it is now used to immobilize the chest for rib fractures and pleurisy.

First, the entire thorax is powdered thoroughly with talcum. The patient slips into a knitted, snugly fitting, buttonless undershirt. Body-size stockinet may be used, but an ordinary undershirt is more simple and effective. The undershirt selected should be of the type which is knitted in tubular fashion to avoid longitudinal seams, and should not have very large armholes. The adhesive strips are three inches in width and long enough to encircle the thorax completely and to overlap several inches. The adhesive is strapped horizontally during complete expiration. The lowest strip is applied first, and each strap overlaps the preceding one by about one and one-half inches. The edges need not be parallel; one should seek rather to get close approximation to the individual thoracic contour.


FIG. 1

This simple method is extremely satisfactory and its advantages are apparent, since it does not require reapplication, and shaving is unnecessary. The strapping does not slip (as it does when applied directly to the skin); the shoulder straps of the undershirt and the close application of the adhesive tape to the natural chest slope keep it firmly fixed. There is no annoying pull on the skin and zinc-oxide excoriation is eliminated. This method of splinting effectively restricts excursion of the thoracic cage without the unpleasant sensation of stickiness.

Infra-red radiation and direct-heat therapy, which are of recognized benefit for pleurisy, do not interfere with the effectiveness of this method.

A SIMPLE ADHESIVE BOOT FOR THE PREVENTION OF FOOT-DROP IN TRACTION-SUSPENSION PROCEDURES

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There have been numerous devices for the prevention of foot-drop in traction and suspension procedures, ranging from leather and web sandals to rather complicated metal affairs. For one reason or another, they have largely been discarded, and resort has been made to a simple adhesive strap on the sole of the foot tied to an overhead traction. The difficulty with this, the simplest possible method, is that the sole of the foot makes a poor surface for the adhesive to stick to, and the adhesive frequently comes off and must be renewed. To overcome this and the other objections, the author has devised an adhesive boot (Figs. 1 and 2) which has proved effective.

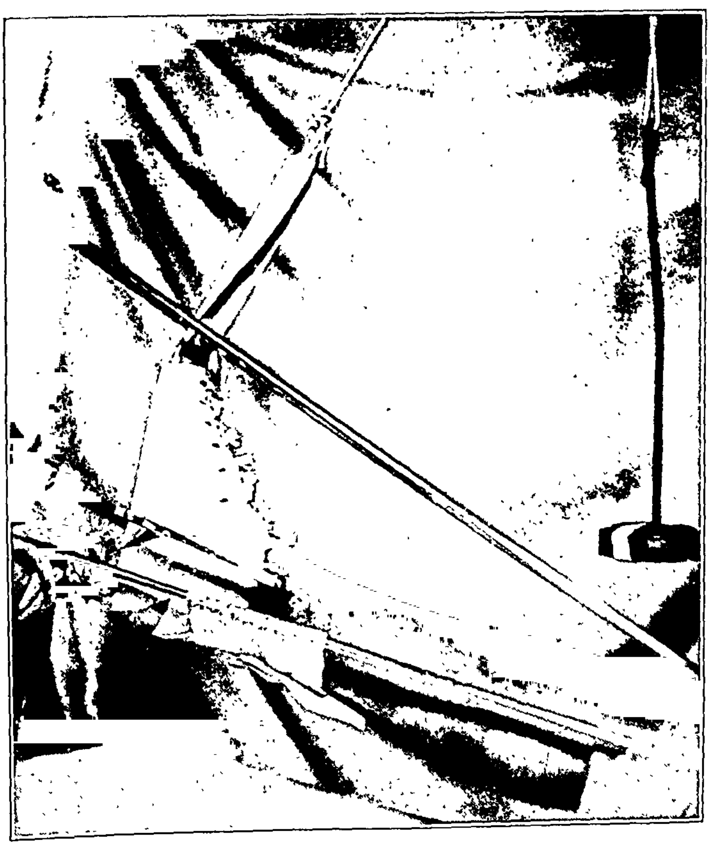

FIG. 1

A large piece of adhesive, twelve inches by twenty-six inches, is used. This is preferably the water-proof type which has a crinoline protection over the adhesive surface, although plain adhesive without the crinoline is quite satisfactory. With the crinoline still adherent, the adhesive is cut with scissors, as shown in Figure 2. The crinoline is then removed except from the strip leading from the toe, to which the traction rope is tied. The holes shown are cut with scissors after the edges have been folded back. The boot is applied to the foot and laced with short lengths of roller bandage (Fig. 1). This gives a close-fitting adhesive boot that is stuck not only to the sole but to all surfaces of the foot and the ankle.

* Service of H. Earle Conwell, M.D.

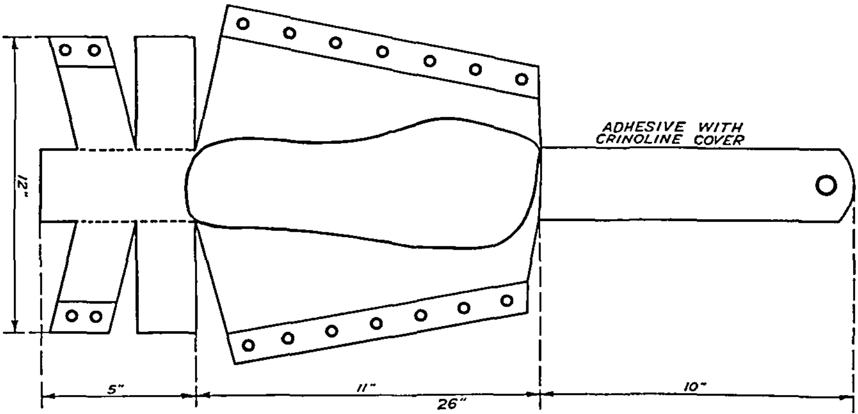

FIG. 2

This apparatus is simple, easily available, and of negligible cost. It can be fitted under a close-fitting traction apparatus, and it does not interfere with active and passive motion of the ankle. Most important, the boot will not come off accidentally.

THE ISCHIAL SEAT BRACE

A Substitute for the Thomas Ring Brace

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The medical profession will always be indebted to Hugh Owen Thomas for the principle of unweighting a pathological lower extremity by transferring the body weight to the ground through the intermediation of a brace with an ischial weight-bearing component. The Thomas ring-brace, which was initially devised for relieving the tuberculous knee of weight-bearing stresses, has long been adopted in various modifications for a wide variety of conditions requiring weight-free function of the lower extremity.

It is a common experience that few brace-makers are able to construct a Thomas ring which is reasonably comfortable and, at the same time, effective. The substitute which is herewith presented aims to provide a support which is readily adjustable to the ischium and which causes a minimum of discomfort to the patient.

The essential feature of this ischial support is a comma-shaped seat made of metal. It is so shaped that it is slightly concave on its superior or ischial surface. The dimensions of the seat vary with the size of the patient; the measurements of a seat made for an adult of average size are given in Figure 3. The comma-shaped plate, which forms the seat, is articulated with the posterior thigh bands of the brace by means of two extension bars (Fig. 1, *B, B*). The plate is mounted on these bars so that the head of the comma-shaped saddle lies directly under the ischium. The concave upper surface of the seat receives and supports the convex surface of the

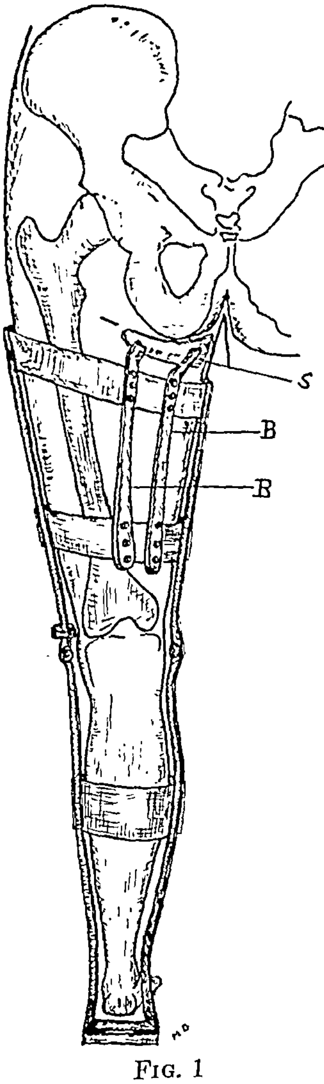


Fig. 1

* Orthopaedic Services of Charles H. Jaeger, M.D., and Harry Finkelstein, M.D.

Fig. 1: Diagrammatic sketch of ischial seat brace, indicating the manner in which the ischium is supported by the seat *S*, which is articulated with the brace by means of the extension bars *B, B*. The seat as sketched is fixed to the extension bars and does not change its position when the patient sits down.

tuber ischii. The tail of the comma-shaped seat is directed laterally along the line of the gluteal fold. The extension bars which join the saddle to the brace are provided with a series of closely placed screw holes, so that accurate adjustment of the seat is possible, both as to height and to inclination. The seat should be amply padded to secure maximum comfort. The author has found a padding of lamb's wool or factis most satisfactory.

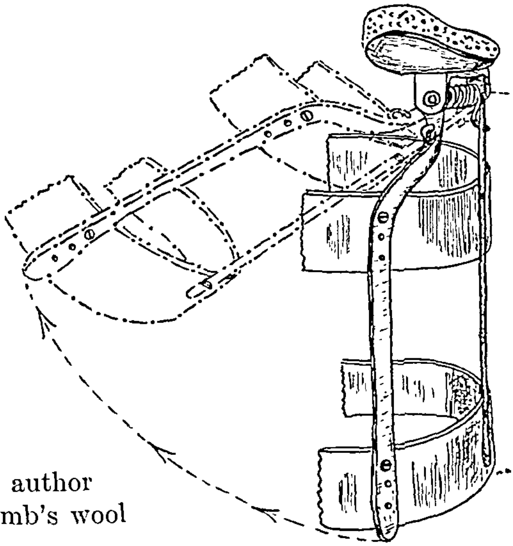


Fig. 2

The articulated seat is illustrated, showing the manner in which the brace flexes anteriorly under the seat in the sitting posture. The coil spring *C* is so articulated that it tends to maintain the seat in position for the standing posture and, when the patient sits, the brace flexes against the moderate spring tension.

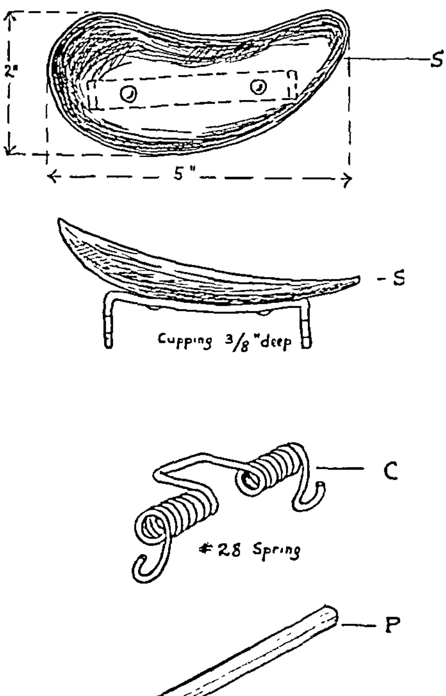


Fig. 3

Illustrating the component parts of the articulated seat. The dimensions of a seat for an adult of average size are indicated. The form of the coil spring *C* is shown. By means of the pin *P*, the spring is articulated with the ischial seat and the extension bars of the brace.

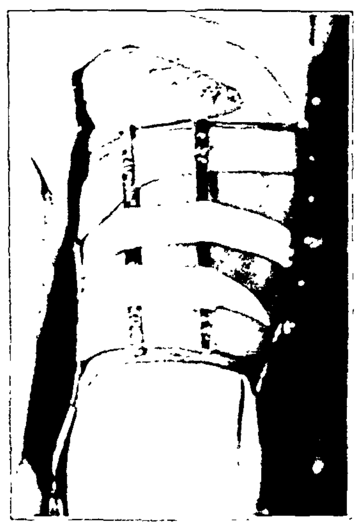


Fig. 4

Photograph of ischial seat in use on a patient with delayed union of a fracture of the shaft of the femur. Note the position of the seat under the ischium. The brace is articulated with a pelvic band.

The seat can be applied to any type of lower-extremity brace, whether a caliper into the shoe, a foot plate, or a patten is used. The device may be used with or without a pelvic band, which is very easily adjusted to this type of brace.

The ischial seat may be made in two distinct types. In the first type, which is the less expensive and the simpler, the seat (Fig. 1, *S*) is riveted to the two supporting bars. This form has the slight disadvantage that when the patient sits down he, of necessity, seats himself on the edge of the saddle. Most patients have experienced no discomfort from this fact, but, in order to overcome this difficulty in the more sensitive individuals, the author has articulated the seat with the two uprights in such a manner that it is capable of rotating around its transverse axis, so that its broad concave surface will face the ischium in either the sitting or the standing posture of the patient (Fig. 2). The rotation of the seat is controlled by means of a coil spring (Figs. 2, *C* and 3, *C*), which maintains the seat normally in the position for standing. The weight of the patient, as he seats himself, maintains a horizontal position of the seat under the ischium. The spring action returns the ischial seat to its normal relative position as soon as the patient arises from the sitting position. This articulated seat is more difficult to construct than is the rigid seat, and is by no means essential to the efficacy of the brace.

There are a number of advantages to the ischial seat in contrast to the Thomas ring. It provides a weight-bearing zone which can be easily and accurately adjusted to the ischium. It eliminates the disturbing pressure of the Thomas ring in the adductor area, a pressure which is difficult to overcome completely. It avoids the bulge which is visible through the clothing laterally where the ring is attached to the external longitudinal bar of the brace. It can be easily applied in double braces without having the seat on one side interfere with that of the other. It may be noted that the use of bilateral Thomas ring-braces is extremely difficult because the rings interfere with each other in the perineum.

SUMMARY

The substitute for the Thomas ring herein presented provides an easily adjustable ischial support which is comfortable and effective. It can be made by any competent bracemaker, and the expense to the patient should be not much more than that of the usual Thomas type of brace.

A NEW PLASTER-OF-PARIS CUTTER *

BY JOSEPH K. NARAT, M.D., CHICAGO, ILLINOIS

A search in the United States Patent Office has disclosed over 100 patents for plaster cutters. The abundance of such devices proves their inadequacy. Most satisfactory results seem to be obtainable from apparatus representing modifications of electric routers. The Leech-Beattie cutter may be considered as the representative of this group. Its disadvantage lies in the necessity of modifying the technique of application of the cast: a core must be placed between the stockinet, or sheet-wadding, and the plaster-of-Paris bandage. Withdrawal of this core from the cast leaves a channel for the cutter.

The following modification of a routing machine, which has been worked out by the author with the help of a mechanic, has been found extremely handy for cutting plaster casts.

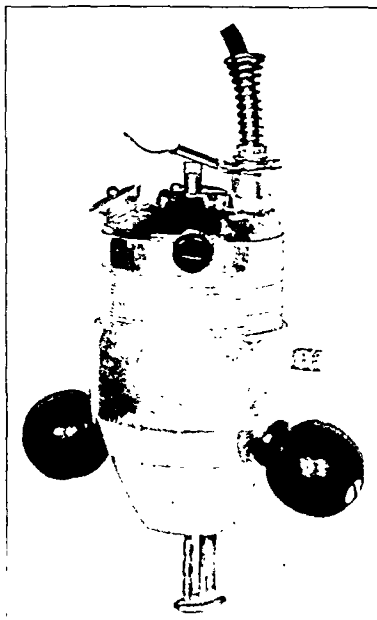


FIG. 1

The portable router is a one-seventh horse-power unit, operating at 18,000 revolutions per minute. The motor is a universal type operating either on direct or alternating current. The diameter of the motor is three inches, the length six inches, and the weight three and one-half pounds. The unit has a patented forced-air-cooling system, which keeps the motor cool under continuous use. Special ball bearings are mounted on each end of the armature to accommodate the high speed. The housing is of strong aluminum alloy, highly polished, and the unit uses a collet type of chuck with a quarter-inch capacity. The motor unit is threaded sixteen threads to the inch to fit the threads in the router base, and turns the motor to the right or left, raising or lowering it,—giving the motor the proper depth adjustment.

Instead of the trigger found in similar devices, the switch has been placed directly on the housing of the motor to which a pair of handles is attached. This arrangement gives a better control of the apparatus.

In comparison with similar devices, this cutter offers the great advantage that it does not require any core: in other words, the usual technique of applying a cast can be employed. The apparatus is powerful

* Demonstrated at the meeting of the Chicago Orthopaedic Club, April 10, 1936.

enough to cut not only the plaster but also any of the customary reenforcements, such as basket splints, flexible metal strips, etc. As the router is protected with a so called shoe, and as the direction of the cutting is not toward the injured limb but parallel with its surface, the danger of trauma is excluded.

A PELVIC-BAND LEG BRACE WITH TWO-WAY MOTION AT THE HIP

BY EDWIN F. PATTON, M.D., LOS ANGELES, CALIFORNIA

From the Clinic of the Los Angeles Orthopaedic Hospital

In leg conditions in which a fixing point above the hip is needed for bracing, and in which flexion and abduction of the hip are permissible, the brace here presented is advantageous.

The principle of allowing lateral motion in addition to the usual forward and backward motion at the hip obviates the necessity of frequent repairs, due to the ripping out of pelvic-band rivets or the wrenching of the hip joint in a brace in which lateral motion is not allowed for. In a bilateral stiff-knee brace, such lateral hinging also permits the patient to go up and down stairs by spreading the legs apart.

The side action is gained by using an *ordinary barn-door* hinge as the upper end of the side bar, instead of the usual solid piece. Figures 1 and 2 illustrate the practical mechanics. There is no loss of desirable fixation as far as the lever arm of the brace is concerned.

FIG. 1

FIG. 2

This appliance has been used after fusion of a knee and in treating bow legs and knock knees. It can be applied in cases in which internal or external rotation of the leg needs to be controlled.

ACUTE OSTEOMYELITIS OF THE SCAPULA (ACROMION PROCESS)

BY W. E. BROGDEN, M.D., CANTON, OHIO

The following case of acute osteomyelitis of the scapula is interesting for two reasons: first, because of its infrequent occurrence; and second, because of the etiological factor.

W. C., a male, aged sixteen years, was admitted to the Orthopaedic Service at Aultman Hospital on February 6, 1936. He complained of pain, swelling, and disability of the left shoulder following a chill twelve hours previously.

On December 15 the patient had sustained a fall on the left shoulder while playing basketball. No treatment had been instituted and recovery was thought complete until January 15, 1936. On this date, incision and drainage of a left axillary abscess had been performed. The sinus had continued to drain seropurulent material. Dressings had been changed daily and the sinus had nearly healed.

Physical examination revealed a patient who looked extremely ill. The temperature was 104.2 degrees; the pulse, 122; and respirations, 32. Examination of the left shoulder showed some redness and induration, which was most marked over the acromion process of the scapula. There was acute tenderness over this region. The axillary abscess was draining moderately.

The laboratory report was as follows: urinalysis, negative; leukocyte count, 21,100. Both the smear and the culture showed long-chained streptococci.

Roentgenographic examination showed an osteomyelitic process involving the acromion process of the left scapula, with cloudiness of the lateral third of the clavicle and the epiphysis of the humeral head. Roentgenographic examination of the left shoulder on January 15 was negative for bone involvement.

Under general anaesthesia, an incision was made along the outer third of the clavicle, across the acromioclavicular articulation and acromion. No purulent material was encountered in this region. Arthrotomy of the shoulder joint with an aspirating needle revealed nothing. The periosteum was incised and retracted. Sequestrectomy was performed on the acromion process of the scapula, and drill holes were placed in the outer third of the clavicle. The bone both of the acromion and of the clavicle was soft and spongy, and a small amount of pus was present. The entire wound was packed open with vaseline gauze. The axillary abscess was explored and evacuated, and approximately half a pint of purulent material was obtained. A Velpeau dressing was then applied.

Twelve hours after the operation, the temperature was 99.6; the pulse, 115; and respiration, 22. The following day the temperature rose to 101 and then dropped to normal where it remained.

On February 8 the dressing was changed, and active motion was permitted. Three weeks later the axillary abscess had entirely healed. Five weeks later the wound on the left shoulder had entirely healed. Ten weeks after the operation the wounds had healed and function of the left shoulder joint was normal.

No doubt the osteomyelitis was the direct result of an improperly drained axillary abscess, and the avenue of infection was the blood stream as no contiguous channel between the abscess and the acromion could be demonstrated. The radical evacuation of the abscess facilitated to a great degree complete recovery and cessation of the osteomyelitic process.

A TRACTION SLEEVE

BY ROBERT T. FINDLAY, M.D., F.A.C.S., NEW YORK, N. Y.

This is a brief description of an article used in the treatment of fractures, which has been thoroughly and successfully tried out on patients in the ambulance of the Beekman Street Hospital in the City of New York during the past three years.

The traction sleeve is an adjustable, one-piece apparatus for application to standard metal splints (Murray-Jones hinged arm splint and Thomas half-ring leg splint) in the treatment of fractures of the extremities at the site of accident and during transportation to a hospital. In conjunction with the splint, the sleeve accomplishes *immobilization*, *traction*, and *suspension* of the injured part. It is considered an improvement over the various methods now in use with the same splints, for the same purpose.

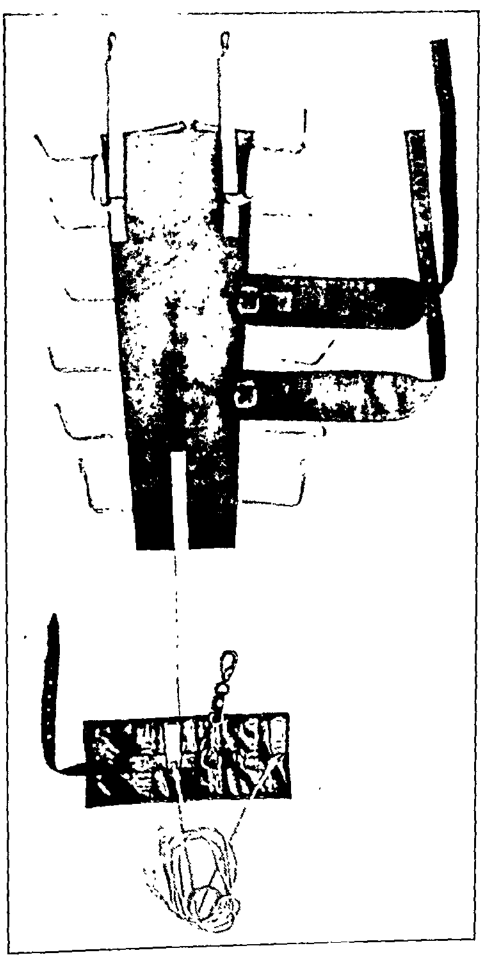


FIG. 1

Figure 1 shows the traction sleeve as a one-piece article, ready for use. The sleeve part is made of heavy sail canvas with a zipper in back. The only purpose of the zipper is to change the canvas to one thickness for scrubbing. When the canvas is opened out to one thickness, it measures twenty-one inches at the top, thirteen inches at the bottom, and thirty inches at the sides. The sleeve slides over the metal rods of the splint (Fig. 2) and, without adjustment, fits the largest size standard leg splint. The two tapes extending upward at the top of the sleeve (Fig. 1) are web tapes, one inch wide and fifteen inches long. These tapes are equipped with adjusting buckles at the bottom and halter clips, with holes one-half an inch in diameter, at the top. These clips fasten to rings at the joints of the splints* and they prevent the sleeve from slipping distally on the splint when the injured extremity is riding on it. The six

* These rings, one on each side, are sewed to the leather ring at the joint of both standard leg and arm splints. There is also added a one-inch web strap, with a two-way buckle, at the top of the leg splint, which straps across the upper thigh. (See Figure 2.)

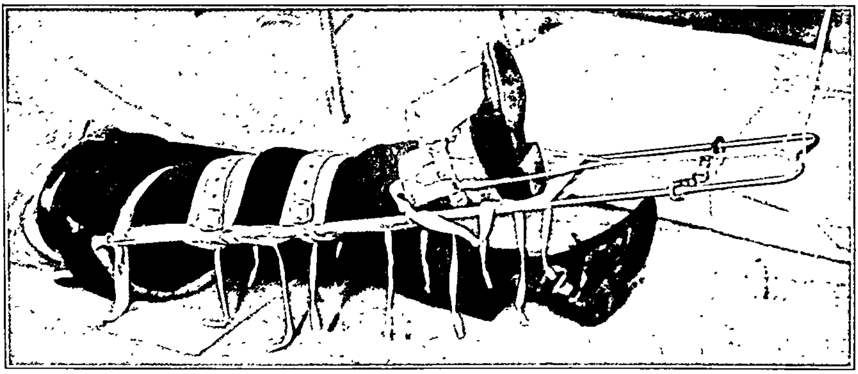


FIG. 2

small tapes coming from the back on each side are half an inch in width and eight inches in length, and are placed five inches apart. These are used to tie across in back in adjusting the width of the sleeve to the width of the splint. The length of the sleeve is adjusted by tucking in the top and the bottom. When tucked in to its full extent—to the attachment of the two one-inch web straps at the top and the one-inch web strap in the center at the bottom—the sleeve fits the smallest standard arm splint.

The two large straps, extending from the right-hand side of the sleeve (Fig. 1), are of heavy canvas with buckles and holes, and fasten completely around the extremity and the splint, above and below the elbow or knee (Fig. 2). Each strap is thirty-three inches long and three and three-fourths inches wide at the buckle and tapers down to the width of the buckle at the holes. There are sixteen holes in each strap, one inch apart, and reenforced with metal. The straps are fastened to the main canvas with metal snappers and are adjustable up and down.

The tape which extends from the center of the lower portion of the sleeve is a one-inch web tape, eighteen inches long, and holds the main canvas to the leather piece below. This is merely to keep the apparatus in one piece. The oblong part, shown near the bottom of Figure 1 (fastened around the patient's ankle in Figure 2), is made of heavy, felt-lined soft leather, fifteen inches by six inches, with a one-inch leather belt attached to the middle. This is to be applied as a secure cuff around wrist or ankle. Attached to the leather cuff by a metal ring and webbing, in positions corresponding to each side of the wrist or ankle, are two strands of clothesline, sixty inches long, which are tied to the end of the splint and which continue for suspension of the splinted extremity.

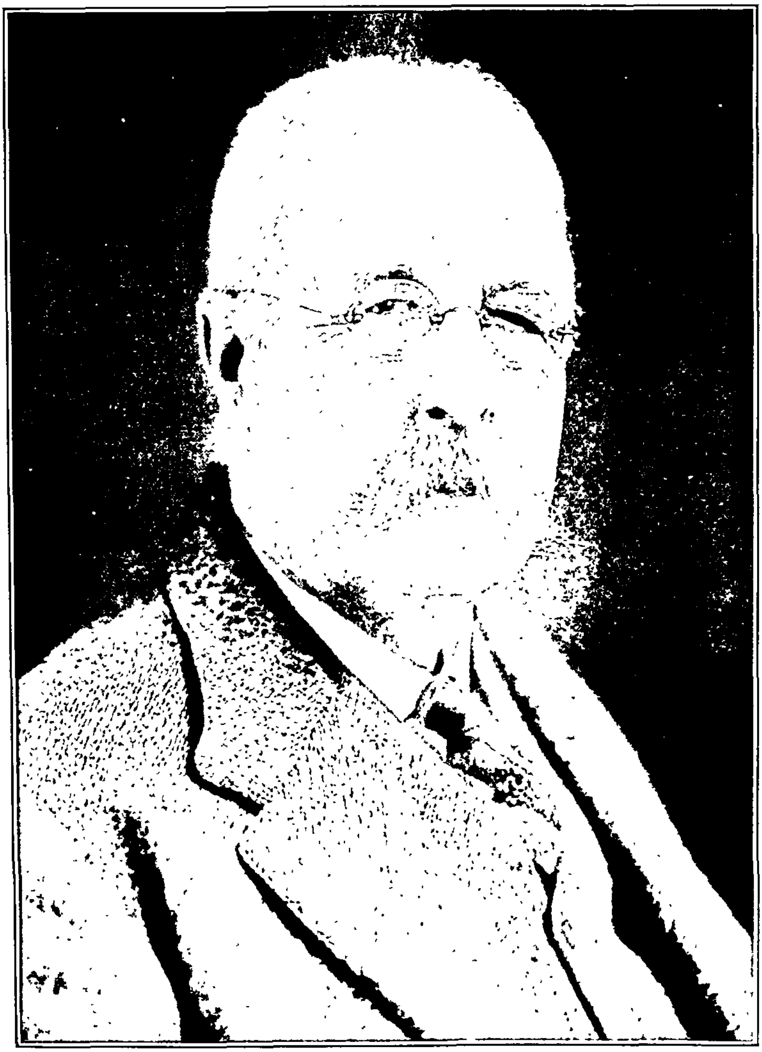
The "winder", which is attached for safe keeping to the buckle of the belt of the cuff in Figure 1 and is seen between the distal end of the sleeve and the end of the splint in Figure 2, is made of two ringed halter clips (with holes one-half an inch in diameter), which are held together with a ring of heavy leather in the center, so that the winder will bend in any direction and adjust its own width. This is placed between the two

strands of clothesline and wound as a Spanish windlass to obtain traction; it is then clamped to the rods of the splint.

CONCLUSIONS

The traction sleeve is washable, non-shrinkable, and nearly indestructible. Several advantages of the sleeve method over other forms of emergency traction have been observed:

1. It is more comfortable to the patient.
2. It may be applied more quickly and gently.
3. It requires less experience and training for its application.
4. It provides even pressure underneath the injured extremity. There is no undue sagging.
5. It does not slip distally on the splint.
6. It is adjustable to either arm or leg splint of any standard size.
7. It is made in one piece, is compact, and the parts are not easily mislaid.
8. Its appearance is neater than most other types of emergency traction apparatus.
9. It is possibly more economical in the long run.



JOHN RIDLON

1852–1936

On April 29, 1936 the American Orthopaedic Association lost its oldest and one of its most distinguished members in the death of Dr. John Ridlon at the Newport Hospital, Newport, Rhode Island. He was eighty-three years old and the only surviving member of the little group of fourteen who met at Dr. Newton M. Shaffer's house in New York in January 1887 to organize the American Orthopaedic Association.

His boyhood was spent on his father's farm in Clarendon, Vermont. He entered Tufts College where, after two years, he was expelled for a misdeed of his room-mate, but truth prevailed and in 1899 Tufts awarded him the honorary degree of Master of Arts and in 1926 the degree of Doctor of Science. After leaving Tufts, Dr. Ridlon went to the University of Chicago where he graduated in 1875. Having decided upon Medicine as a career, he graduated in 1878 from the College of Physicians and Surgeons of

Columbia University, New York, and in the same year he received the degree of Master of Arts from the University of Chicago.

Dr. Ridlon served as intern at St. Luke's Hospital, New York, from 1878 to 1880. He was then appointed Assistant Attending Orthopaedic Surgeon at the New York Orthopaedic Dispensary and Hospital, and Instructor in Orthopaedic Surgery at the New York University Medical School. He was also a surgeon of the First Orthopaedic Division of the Out-Patient Department of Bellevue Hospital, and Assistant at the Vanderbilt Clinic.

On June 4, 1879, he married Emily Caroline Robinson of Newport, Rhode Island.

In 1891 he moved to Chicago, where he became Professor of Orthopaedic Surgery in Northwestern University Medical School, a position which he held until 1908. From 1908 until 1911 he was Professor of Orthopaedic Surgery at Rush Medical College of the University of Chicago. He was also Professor of Orthopaedic Surgery at the Woman's Medical School of Northwestern University and at the Chicago Post-Graduate Medical School.

At the same time he was Attending Orthopaedic Surgeon at St. Luke's Hospital and Michael Reese Hospital, the Home for Destitute Crippled Children, and the Convalescent Home for Crippled Children of which he was one of the founders. He was also active in establishing the Jesse Spaulding School for Crippled Children, now one of the outstanding institutions of its kind in the world.

From the founding of the American Orthopaedic Association in 1887 until his retirement in 1929, Dr. Ridlon was one of the most outstanding and devoted members of that body. He was elected Secretary in 1890 and President in 1894. He was again elected Secretary in 1895 and served in that capacity until 1906. He rarely, if ever, missed a meeting of the Association up to the time when he moved to Newport.

Dr. Ridlon entered the Military Service in 1917 as orthopaedic instructor, and served at various posts. In January 1918 he organized the School of Instruction for Orthopaedic Medical Officers in Chicago. The teaching which he supervised was carried out at the various medical schools and hospitals. When the course was finished in the summer of 1918, he carried on orthopaedic instruction in the Army Medical School at Camp Greenleaf and other posts until the Armistice.

About seven years ago Dr. Ridlon moved to his summer home in Newport, Rhode Island, to live permanently. He was then active for the first five years and did consulting work at the Newport Hospital and the Newport Naval Hospital. At the latter institution he suggested to the Commandant the advisability of a weekly consultation visit, and continued this activity for some time.

He also interested himself in the affairs of the American Legion and gave freely of his time and effort to the veterans' problems. An examination of all the school children of Newport for faulty posture was an outstanding instance of his energy at the age of eighty. During this period he was a fairly regular attendant at the meetings of the Boston Orthopaedic Club and of the Rhode Island Medical Society. At one of the meetings of the latter society he presented an excellent paper on congenital dislocation of the hip, discussing the subject from all angles with a comprehensive differential diagnosis. About three years ago he was elected President of the Newport Medical Society and served for one year. He carried on a large correspondence and worked each day diligently on his memoirs.

His contributions to the literature of Orthopaedic Surgery consist of about 125 articles, but he will probably be best remembered for his writings on congenital dislocation of the hip, through which he made a real contribution to the subject.

A visit which Dr. Ridlon made to Hugh Owen Thomas in 1887 at Liverpool resulted in lifelong friendships with Mr. Thomas and with his nephew, Robert Jones. He was very deeply impressed with the soundness of Thomas' views regarding diseased joints and the necessity for rest in their treatment, and he remained a most ardent advocate and teacher of those principles all his life. In 1899 he collaborated with Sir Robert Jones in a treatise on Orthopaedic Surgery, in which the writings and teachings of Hugh Owen

Thomas were more fully elaborated, and "modified by their own personal experience and convictions". It is a little volume which would well repay the reading by every young orthopaedic surgeon of today.

Dr. Ridlon was a man of great energy, and an indefatigable worker, with the necessary patience to follow out the most obstinate cases with unflagging interest, and he was always trying to work out a better method for securing the results which he felt should be obtained.

He was given to thinking straight and reasoning logically, and when he had come to a conclusion he was ready to defend it against all comers. With his striking and dominant personality, this brought him into argumentative conflict with some of his confrères, but without resentment or animosity. His gift for teaching objectively and the thoroughness of his work always secured the interest and admiration of his students and assistants. The most loyal and devoted of his lifelong friends were those who had been associated with him in his clinical teaching and private practice and had had an opportunity to know the man as well as the teacher. He had the gift of being able to stimulate the interest and enthusiasm of the younger men who came under his influence, and many of the men who in later years have achieved prominence in Orthopaedic Surgery, especially those in the Middle West, owe much of their success to the encouragement, advice, and inspiration which they received from him. Not only to the members of the American Orthopaedic Association, but also to his many professional friends of the younger generation elsewhere, he was affectionately known as "Uncle John". In his death we have lost a great member of our profession.

News Notes

The Fiftieth Annual Meeting of the **American Orthopaedic Association** was held in Milwaukee, Wisconsin, at the *Hotel Schroeder on May 18 to 21, under the presidency* of Dr. Frederick J. Gaenslen.

The first day was a clinical day, and cases were presented by Dr. Gaenslen and his associates in Milwaukee. A golf tournament was held on the afternoon of the first day. The remaining portion of the Meeting was given over to the presentation of papers, as follows:

TUESDAY, MAY 19

Morning Session

President's Address.
 Dr. Frederick J. Gaenslen, Milwaukee, Wisconsin.
History of Fracture Treatment.
 Dr. William Arthur Clark, Pasadena, California.
New Operative Procedure for Instability of the Knee Joint.
 Dr. H. Page Mauck, Richmond, Virginia.
Treatment of Intercondylar Fractures of the Elbow Joint with Skeletal Traction.
 Dr. Rudolph S. Reich, Cleveland, Ohio.
Fractures and Fracture-Dislocation of the Cervical Spine.
 Dr. William G. Turner, Montreal, Canada.
 Dr. William Cone, Montreal, Canada.

Afternoon Session

Fractures of the Acetabulum with Subluxation of the Hip.
 Dr. Willis C. Campbell, Memphis, Tennessee.
Series of Fractures of the Neck of the Femur, United with Excellent Functional Results after Treatment by Means of Smith-Petersen Nail.
 Dr. Lawson Thornton, Atlanta, Georgia.
 Dr. Calvin Sandison, Atlanta, Georgia. (By invitation.)
Inclination of the Pelvis and Acetabulum as a Causative Factor in Slipped Epiphysis and Non-Union in Fractured Hips.
 Dr. Lloyd T. Brown, Boston, Massachusetts.
Analysis of Results of Early Treatment of Congenital Dislocation of the Hip by Manipulation and Osteoclasis for Anterior Distortion.
 Dr. Arthur Krida, New York, N. Y.
 Dr. Paul Colonna, New York, N. Y.
 Dr. Francis J. Carr, Jr., New York, N. Y. (By invitation.)

WEDNESDAY, MAY 20

Morning Session

Septic Hips: A Study of End Results.
 Dr. Carl E. Badgley, Ann Arbor, Michigan.
Acute Osteomyelitis. Treatment in the Light of Recent Serological Findings. (Read by title.)
 Dr. D. E. Robertson, Toronto, Canada.
Primary Point of Infection in Tuberculosis of the Hip.
 Dr. Dallas B. Phemister, Chicago, Illinois.
 Dr. C. Howard Hatcher, Chicago, Illinois. (By invitation.)

The Occurrence of Abscesses from Hips That Are Firmly Ankylosed.
Dr. Z. B. Adams, Boston, Massachusetts.
Treatment of Bursitis.
Dr. M. N. Smith-Petersen, Boston, Massachusetts.
Dr. Paul Norton, Boston, Massachusetts. (By invitation.)
Bone Metabolism.
Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
Dr. Irvin Stein, Philadelphia, Pennsylvania. (By invitation.)

Afternoon Session

Wave Mechanics of Muscle Motion.
Dr. Eben J. Carey, Milwaukee, Wisconsin. (By invitation.)
Fascial Transplants in Infantile Paralysis and Other Conditions Involving Weakness of the Muscle Groups.
Dr. Frank Dickson, Kansas City, Missouri.
Correction of Paralytic Drop-Foot by Tendon Transplantation.
Dr. Leo Mayer, New York, N. Y.
Factors Influencing the Balance of the Foot in Walking.
Dr. R. Plato Schwartz, Rochester, New York.

THURSDAY, MAY 21

Morning Session

An Inquiry on Articular Pain.
Dr. J. G. Kuhns, Boston, Massachusetts.
Dr. H. L. Weatherford, Boston, Massachusetts. (By invitation.)
Auscultation of Joints.
Dr. Arthur Steindler, Iowa City, Iowa.
Chronic Atrophic Arthritis.
Dr. Theodore A. Willis, Cleveland, Ohio.
Treatment of Giant-Cell Bone Tumors.
Dr. H. W. Meyerding, Rochester, Minnesota.
Arthrotomies for Internal Derangement of the Knee Joint. (Read by title.)
Dr. Paul P. Swett, Hartford, Connecticut.

The Annual Dinner was held on Wednesday evening, May 20, at The Wisconsin Club.

At the Executive Session held on May 19, the following were elected to membership:
Dr. Mather Cleveland, New York, N. Y.
Dr. Joseph E. Milgram, New York, N. Y.
Dr. Alan DeF. Smith, New York, N. Y.
Dr. W. E. Wolcott, Des Moines, Iowa.

The officers for the ensuing year are:
President: Dr. H. Winnett Orr, Lincoln, Nebraska.
President-Elect: Dr. Frederick C. Kidner, Detroit, Michigan.
Vice-President: Dr. William G. Turner, Montreal, Canada.
Treasurer: Dr. John L. Porter, Evanston, Illinois.
Secretary: Dr. Ralph K. Ghormley, Rochester, Minnesota.
Member of Membership Committee: Dr. Philip D. Wilson, New York, N. Y.
Member of Program Committee: Dr. Carl E. Badgley, Ann Arbor, Michigan.
Delegate to The American College of Surgeons: Dr. W. C. Campbell, Memphis, Tennessee.
Delegate to The American Board of Orthopaedic Surgery: Dr. M. S. Henderson, Rochester, Minnesota.

The next Meeting will be held in Lincoln, Nebraska, under the presidency of Dr. H. Winnett Orr.

The Spring Meeting of the **British Orthopaedic Association**, under the presidency of Mr. W. R. Bristow, was held from April 22 to 26 in Brussels at the invitation of the Belgian Surgical and Orthopaedic Societies, who met under the presidencies of Dr. Huston and Dr. Van Haelst.

The three days were spent in visiting the orthopaedic and surgical clinics of Brussels and in discussing various orthopaedic subjects. The main subject was introduced by Prof. Parisel who, with Dr. Serbzt, presented a report on "Apophysitis of the Tibial Tubercle (Osgood-Schlatter Disease)". In the discussions which followed no new light was thrown on its pathogenesis. It was generally agreed that: (1) trauma plays an exciting rôle, possibly by interference with the blood supply of the growing tibial tubercle; (2) adequate treatment consists in the avoidance of overstrain during the active phase of the "disease". In exceptional cases operation may be necessary for the removal of troublesome calcareous deposits in the region of the tubercle.

The following short communications were also presented:

Osteosynthesis of Transverse Fractures of the Femoral Shaft.
Prof. J. Verbrugge (Anvers).

Some Operations of Reparative Surgery.
Prof. Dehez (Liége).

Congenital Elevation of the Scapula.
Prof. Maffei (Brussels).

Some Roentgenograms of Congenital Dislocations of the Hip.
Prof. Maffei (Brussels).

Trial of Surgical Treatment for the Prevention of Deformity in Adolescent Coxa Vara.
Prof. Delchef (Brussels).

Epidural Lipiodol Exploration in Spina Bifida Occulta.
Prof. Delchef (Brussels).

The Association Dinner was held in *La Taverne Royale;* the Presidents and members of the Committee of the Belgian Societies were the guests of the Association.

The Ladies' Committee of the Belgian Societies had arranged tours in and around the city, which were keenly enjoyed by the visiting ladies.

The Annual Meeting of the **British Orthopaedic Association**, will be held in London on October 30 and 31, 1936, under the presidency of Mr. W. R. Bristow.

The First Congress of the **Sociedad Española de Cirugía Ortopédica y Traumatología** was held in Barcelona on June 19 to 22. The subjects chosen for discussion at this meeting were "The Pathology of Hydrarthrosis", "Medullary Compression in Pott's Disease", and "Operative Treatment of Recent Fractures of the Long Bones".

Dr. H. Earle Conwell announces his association with Dr. John D. Sherrill, 216-222 Medical Arts Building, Birmingham, Alabama.

The First **International Congress of Sanatoria and Private Nursing Homes** will be held in Budapest in the latter part of September 1936. Short abstracts of lectures, discussions, proposals, etc., should be sent as soon as possible to the Committee, Margitsziget Sanatorium, Budapest.

The **American Public Health Association** will convene in New Orleans, Louisiana, on October 20 to 23 for its Sixty-Fifth Annual Meeting. A report on the state of the nation in matters of public and personal health will be presented. The President-Elect of the Association is Dr. Thomas A. Parran, Jr., Surgeon General of the United States Public Health Service, and the Executive Secretary is Dr. Reginald M. Atwater. National headquarters of the Association are at 50 West 50th Street, New York, N. Y.

The **Deutsche Orthopädische Gesellschaft** will hold its next Congress in Königsberg Pr. on August 28, 29, and 30, under the presidency of Prof. Dr. Lothar Kreuz. On the first day the morning session will be devoted to discussions on "The Rôle of Orthopaedic Surgery in Congenital Deformities", and in the afternoon the subject to be considered will be "The Rôle of Orthopaedic Surgery in Hygiene". On the following days the papers to be presented will deal with: "The Knowledge and Treatment of Talipes Calcaneus", "The Biology of Amputations", "The Pathological and Clinical Considerations of Acute Lumbago", and "The Origin, Prevention, and Treatment of Ankylosis".

The Eighteenth Annual Meeting of the **Société Française d'Orthopédie** will take place in Paris on October 9 and 10, under the presidency of Prof. Le Fort. The questions to be considered are "Spondylolisthesis" and "Abnormal Callus of the Instep".

The Clinical Days of the **Société Française d'Orthopédie** will be held in Turin on September 18, 19, and 20, under the direction of Prof. Ugo Camera. The opening meeting will be held at the *Ospedale "Regina Margherita"*. At a session at the *Clinica Chirurgica*, Prof. Uffreduzzi will present cases and there will be demonstrations of technique, including surgery of the hip, treatment of inequality of leg length, treatment of the sequelae of poliomyelitis, treatment of congenital club-foot by tendon grafts, etc. An attractive program of excursions in Turin and the neighboring country has been arranged.

The First **International Conference on Fever Therapy**, originally scheduled for the end of September 1936, has been postponed to permit more time for the preparation of material. The new dates set for this Conference are March 30 to April 2, 1937. The sessions will be held at the College of Physicians and Surgeons, Columbia University, New York City. A tour has been arranged to take place immediately after the Conference to enable physicians to observe the techniques employed in fever therapy in some of the hospitals in the eastern section of the United States. Among the institutions to be visited are: the Strong Memorial Hospital of the University of Rochester, Rochester, New York; the Henry Ford Hospital, Detroit, Michigan; The Mayo Clinic, Rochester, Minnesota; the Kettering Institute for Medical Research at the Miami Valley Hospital, Dayton, Ohio; and Northwestern University Medical School, Chicago, Illinois. Further information regarding the Conference may be obtained from the General Secretary, Dr. William Bierman, 471 Park Avenue, New York, N. Y.

The **Sociedad Argentina de Cirugía Ortopédica**, which has just been founded in Buenos Aires, announces the election of the following officers:

Chairman: Dr. Luis A. Tamini
Vice-Chairman: Dr. José Valls
Secretary: Dr. Carlos E. Ottolenghi
Treasurer: Dr. Pedro H. Garavano

The Third Congress of the **International Society of Orthopaedic Surgery**, which is to be held in Bologna, Italy, will open on September 21 with a General Assembly. Prof. Vittorio Putti is the President of the Society and the President's Dinner will take place on the evening of the opening day. The next three days will be devoted to a presentation and discussion of papers. On the afternoon of September 24 the members will leave for Rome and on the next day they will have opportunity to visit the new Clinic of Orthopaedic Surgery in Rome and to observe various clinical demonstrations there. There will also be an exhibition at the *Istituto Rizzoli* to show the progress achieved in the surgery of the locomotor apparatus. This exposition will include a scientific section and a technical section.

The meeting of the **Orthopaedic Section of the American Medical Association** was held in Kansas City, Missouri, on May 13, 14, and 15. On the first afternoon the

Chairman, Dr. Arthur T. Legg, presented his address on "The Early Orthopaedic Treatment of Poliomyelitis". The rest of the first day was allotted to the papers and discussions on "Fractures of the Neck of the Femur".

On the second day there was a symposium on Osteomyelitis including "Growth Changes in Bone" and "Late Infection Due to the Use of Wire and Pins".

At the business session on May 15 the following officers were elected for the coming year: Dr. Fremont A. Chandler, Chairman; Dr. John Dunlop, Vice-Chairman; Dr. Robert V. Funsten, Secretary. Dr. J. S. Speed, Dr. Robert Schrock, and Dr. Arthur Legg were appointed to the Executive Committee. Dr. Henry W. Meyerding continues his appointment to the House of Delegates with Dr. Roland Hammond and Dr. J. S. Speed as alternates.

The remainder of the meeting was devoted to a general program including tuberculosis, bone-grafting, slipped femoral epiphysis, correction of faulty posture, and habitual dislocations of the shoulder.

At the annual meeting of the **Deutsche Gesellschaft für Unfallheilkunde, Versicherungs- und Versorgungsmedizin**, held in Berlin on October 18 and 19, 1935, the problems relative to some of the general questions of insurance, hygiene, heredity, and growth were discussed and papers were presented by Prof. Hübner (Berlin), Prof. Schmidt (Remscheid), Prof. Dersch (Berlin), Prof. Charlton (Berlin), Prof. Kuhr (Berlin), Prof. Zollinger (Zurich), Prof. Scholtze (Berlin), Prof. Weiler (Munich). Prof. Blencke (Magdeburg) and Prof. Thomsen (Frankfurt a.M.) discussed some of the questions pertaining to the type and use of apparatus employed in the treatment of orthopaedic and traumatic conditions and emphasized the need of more attention on the part of the surgeon in its application. Prof. Schmieden (Frankfurt a.M.) and Prof. Sauerbruch (Berlin) called attention to the importance of and gave suggestions in regard to the treatment of wounds about the thorax. Prof. Häbler (Würzburg) combatted the claim that the presence of metallic substances causes decomposition and atrophy of bone in osteosynthesis. Prof. Baader (Berlin) gave some of the results of the use of phosphorus in industry. Prof. Sommer (Dortmund) reported on some of the disturbances following the use of antitetanic serum. Prof. zur Verth discussed the difficult question of the desirable length of the stump in amputations of the leg below the knee. As a result of his experience, he believes that the stump should not be longer than one-half the length of the leg from the knee to the foot.

The next meeting will be held in Hamburg, September 17 and 18, 1936, under the presidency of Prof. Dr. M. zur Verth. The subjects to be considered are "Heredity and Constitution in Their Relation to Insurance" and "Injuries to the Meniscus". A most cordial invitation to attend this meeting is extended to the members of the American Orthopaedic Association and of the American Academy of Orthopaedic Surgeons.

The **Sociedade Brasileira de Orthopedia e Traumatologia** has recently been organized in São Paulo with the object of stimulating and perfecting the study and practice of orthopaedic and traumatic surgery. The Society has among its founders those surgeons who are specializing in these subjects, and its members decided to establish headquarters in São Paulo because of the development of the Orthopaedic School there. The Society plans to hold sessions regularly in the various states as well as in the central office. The annual meetings will be held in the capital of each state successively.

The officers elected at the organization meeting were:

President: Prof. Dr. Luiz de Rezende Puech
Vice-President: Dr. Domingos Define
General Secretary: Dr. Renato da Costa Bomfim
Assistant Secretaries: Dr. Itapema Alves and Dr. Odair Pedroso
Treasurer: Dr. Domingos M. Rezende
Librarian: Dr. Ulysses Barbuda

In addition to these, editorial and advisory committees were appointed.

The first annual meeting was held in June of this year under the presidency of Prof. Dr. Rezende Puech, and was attended by Dr. Vittorio Putti of the Italian Orthopaedic School in Bologna, and also by Brazilian members of the profession.

Prof. Putti spoke on "Orthopaedic Surgery in Contemporary Medicine" and showed that orthopaedic surgery as it has developed has come to include most of the surgery of the locomotor apparatus and that traumatology is, therefore, closely allied with it. Prof. Rezende Puech presented an excellent discussion on the question of "Anterior Tibiotarsal Arthrodesis by Bone Graft in the Treatment of Old Paralytic Talipes Calcaneus". Prof. Barros Lima contributed an interesting study on new aspects of the treatment of osteoarticular tuberculosis in Brazil.

During the closing session Prof. Vittorio Putti (Bologna), Dr. Fred Albee (New York), and Prof. Ombrédanne (Paris) were elected Honorary Members.

The next Congress will take place in Rio de Janeiro in July 1937, under Prof. Achilles de Araujo, the newly elected President. The following subjects have been chosen for discussion: "Congenital Dislocation of the Hip in Brazil" and "Fractures of the Neck of the Femur".

The First Congress of the **Ukrainian Society of Orthopaedic and Traumatic Surgery** took place on January 24 to 28, 1936, at Kharkov, U. S. S. R.

Since 1925, at each surgical congress one day has been allotted to the consideration of orthopaedic surgery. This time was filled with the discussion of important questions arising in orthopaedic and traumatic surgery, and the necessity of organizing a special congress finally became evident. Some difficulty was encountered in the final arrangements, but this year it was decided to call the First Congress of the Ukrainian Orthopaedic Surgeons. Four hundred orthopaedic surgeons from the different parts of the Union were present and the meeting acquired the character of an All-Union Congress. The committee in charge of the meeting was of the opinion that the First Congress should pay special attention to the question of organization.

The first day was devoted to questions which have an important bearing on orthopaedic surgery, such as the system of health preservation, medical education, fundamental principles of classification and registration in orthopaedic surgery, the necessity of uniform nomenclature, typical records of cases, orthopaedic prophylaxis for children, and types of orthopaedic institutions. Papers on these subjects were read by delegates from different parts of the Union. The question of the rôle which orthopaedic surgery should play in the matter of medical education called forth some controversy,—its place among other subjects, the question of the number of lectures to be assigned, and also whether trauma of the locomotor apparatus should be included under orthopaedic surgery. Special stress was laid on the importance of the uniformity of standards for the registration of orthopaedic patients.

The second day was devoted to the question of traumata of the locomotor apparatus. The principal subject on this program was injuries due to machine labor, and especial attention was paid to methods of reducing the frequency of these injuries. A series of reports dealt with cases of trauma occurring in street traffic. There were also a number of reports on methods of economizing the capacity for work which remains after diseases or injuries to the locomotor apparatus, and also on the use of prostheses for workmen.

On the third day the question of poliomyelitis was considered. Thirty reports were presented dealing with the conservative and the operative treatment of the consequences of poliomyelitis. A series of reports were devoted to the results of operative treatment, transplantation of tendons, astragalectomy and arthroereisis.

The fourth and last day was devoted to arthroplasty, and a number of orthopaedic surgeons presented their experience in dealing with this procedure.

At the same time an exhibition was arranged with interesting exhibits of different phases of orthopaedic work, which bore witness to the success of the young Soviet orthopaedic surgeons.

The next Congress will take place in 1937 in Leningrad.

Current Literature

Die orthopädische Weltliteratur. Edited by Prof. Dr. August Blencke and Prof. Dr. Hermann Gocht. II. Band. Stuttgart, Ferdinand Enke, 1936. Two volumes, 196 marks, less a discount of 25 per cent. to purchasers outside of Germany.

The second of the two volumes of "Die orthopädische Weltliteratur", edited by Dr. Blencke and Dr. Gocht with the collaboration of a large number of very prominent orthopaedic surgeons in different parts of the world, has recently appeared. The first volume met a great need for a comprehensive collection of the world literature and included references to the general subjects connected with orthopaedic and traumatic surgery. The second volume is confined to subjects of distinct orthopaedic interest. The references are indexed under the authors' names in fifteen groups, so that the reader has easy access to the literature pertaining to the special subject in which he is interested. The grouping is as follows:

Deformities and Diseases of the Neck and Head;
Deformities and Diseases of the Thorax and Shoulder Girdle;
Posture, Malposture, Scoliosis, and Kyphosis;
Tuberculous Spondylitis;
Deformities and Diseases of the Spine; Back Pain and Lumbago;
Deformities and Diseases of the Upper Extremity;
Deformities and Diseases of the Pelvis and Ischium;
So Called Congenital Dislocation of the Hip;
Tuberculous Hip Disease and Its Sequelae;
Coxa Vara, Coxa Valga, Malum Coxae, and Other Diseases and Deformities of the Hip;
Genu Valgum, Genu Varum, and Genu Recurvatum;
Deformities and Diseases of the Upper and Lower Extremities and of the Knee Joint;
Pes Equinus, Equinovarus, and Various Deformities of the Foot;
Flatfoot, Pronated Foot, and Splayfoot;
Diseases and Deformities of the Joints of the Foot and of the Toes.

The more extensive interchange of medical and surgical studies from the different countries and the increasing contributions from many countries which a few years ago did not produce any appreciable amount of literature dealing with orthopaedic problems are factors which have played important rôles in making this volume a valuable addition to the library of the orthopaedic surgeon.

Emergency Surgery. By Hamilton Bailey, F. R. C. S. (Eng.). Baltimore, William Wood & Co., 1936. $14.00.

It is very appropriate that this excellent book should open with chapters on "Intravenous Infusion", "Blood Transfusions", "Anaesthesia for Urgent Operations", and "Armamentarium". This is a book on *emergency surgery*. Everything is short and to the point. In regard to the sterilization of the patient's skin, one sentence is enough: "The iodine preparation of the skin has stood the test of time, and for urgent cases it is unsurpassed."

When the various types of surgical operations are considered, the instruments needed are described and illustrated, the incisions to be used are shown, and in many instances the pathological conditions are illustrated in color. Pitfalls, complications, short cuts, and operative approaches are discussed briefly.

Abdominal and thoracic surgery receive by far the greatest amount of attention. The excellent chapters on bones and joints possibly are not complete enough. The treat-

ment of simple fractures is not mentioned. Compound fractures rate only a short chapter of ten pages.

Some of the procedures in the operative treatment of compound fractures are open to criticism. The paragraphs on the Carrel-Dakin method are good but inadequate. The Orr treatment is mentioned briefly for complications arising from compound fractures.

Dislocations assume their place in this volume and the usual manipulations for their reduction are indicated. The chapter is well illustrated. Aspiration and drainage of joints in acute suppurative arthritis are well described and illustrated. The chapters on "Nerves and Tendons", "Lacerations of the Hand", and "Infections of the Hand" are all good.

One of the best chapters in the book is the one on "Urgent Amputations". The text and the plates are well prepared. The important details of the best levels for amputation, the operative technique, and the application of artificial limbs are thoroughly described.

LES OSTÉOTOMIES SOUS-TROCHANTÉRIENNES DANS LE TRAITEMENT DES LUXATIONS CONGÉNITALES INVÉTÉRÉES DE LA HANCHE. By Pierre-Marcel Lance. With a Preface by Pr. Ombrédanne. Paris, Masson et C^{ie}, 1936. 30 francs.

The author states that the experience of the last few years with osteotomies has been sufficient to warrant the deduction of the indications and the development of a safe and sure technique. In this book he confines his study to the subject of subtrochanteric osteotomy, with particular attention to the bifurcation operation of Lorenz. He gives an excellent description of the pathological anatomy both of the bones and of the muscles which are associated with malposition of the pelvis, etc.

In this book osteotomies are divided into two groups: those performed with the object of changing the direction of the femur, and those done to give pelvic support. In considering the first group, the author reviews the various methods and types of osteotomies, beginning with that advocated by Kirmisson. He discusses the indications and also the problems which may arise in connection with this operation. Many cases are cited to illustrate the various deformities for which this procedure is indicated.

In discussing the second group, the author considers in detail the bifurcation operation of Lorenz, including a short review of its first use, its reception, and its employment in the early years. He then discusses the defects and failures of this operation and of other forms of osteotomy and the general considerations which must be borne in mind in the employment of subtrochanteric osteotomies performed with the object of giving pelvic support. He next reviews the anatomical and mechanical factors in order to explain the defects of this operation which places the upper end of the lower fragment in the imperfect acetabulum, a practice which he considers to be unsound and frequently unsatisfactory. The advantages and disadvantages of this method are discussed in detail, and the author is distinctly in favor of its modification. One of the most important results of the modified method is the very satisfactory correction of the tilting of the pelvis.

The high osteotomy of Froelich and the low osteotomy of Schanz are discussed and compared with the usual methods of osteotomy. Cases are cited which illustrate the conditions in which these methods are used and the results, both favorable and unfavorable, are given.

The criticisms which the author makes in regard to the various methods are accompanied by suggestions as to the procedures which may be employed to meet the objections. The different methods which are described are illustrated by cases and excellent roentgenograms. Not only are the favorable results given, but the failures are also included, with the reasons for failure in many cases. The book is well illustrated with photographs, roentgenograms, and drawings, and a very comprehensive bibliography is appended.

American Martyrs to Science through the Roentgen Rays. By Percy Brown, M.D., F.A.C.P., F.A.C.R. Springfield, Illinois, Charles C. Thomas, 1936. $3.50.

In this book Dr. Brown pays tribute to the pioneers who sacrificed themselves in the early development of the use of the roentgen ray and who, by that sacrifice, gave to mankind one of the most signal benefits of modern times. Dr. Brown, himself a pioneer, is well equipped for this task and has given a presentation which is evidently the result of a labor of love.

Preceding the biographies of the representatives of this group, which is confined to American roentgenologists, Dr. Brown furnishes the reader with an interesting historical sketch of some of the more important and interesting phases in the development of this therapeutic agent and of the difficulties which these pioneers were obliged to overcome. Also included is a history of the long period in which these men were subjected to the dangers of the roentgen ray before these dangers were recognized, and of the still longer period before adequate protection was afforded these operators. This portion of the book is also full of interesting information on the mechanical and scientific as well as the clinical work which was necessary for the development of this specialty in the early days before the value of the roentgen ray had received adequate recognition. The author emphasizes the enthusiasm of the pioneers for their work and their belief at that time in the future of their specialty.

Dr. Brown pays tribute to each of the men whose biographies appear in this volume, and his personal contact with a large number of them enabled him to portray much of their characters which otherwise would have remained unrevealed. In the discussion of their lives he has included the special contribution which each has made to the development of the roentgen ray.

It is fortunate that Dr. Brown was prompted to perpetuate in this way the record of the sacrifice which these men have made in their contributions to this branch of medicine. The reader will find the book extremely interesting, and the personal element, which is evident throughout, adds very materially to its attractiveness.

Die Nachbehandlung nach Operationen. By Prof. Dr. Paul Reichel. 3. Aufl. Berlin, Julius Springer, 1936. 25.80 marks.

The first edition of Prof. Reichel's book on postoperative treatment was published in 1896. The third edition, which has just been issued, is based on more than thirty years' experience as the director of a large Surgical Service. The subject of postoperative care has not always received the attention which is due so important a part of the treatment; operative technique has attracted the greater attention. It is encouraging, therefore, to see that the field is being covered and that the demand for expert information has resulted in this third revised and enlarged edition.

This book covers the entire field of surgery. The larger portion is devoted to general surgery, but there is a very generous section given up to subjects bearing on orthopaedic and traumatic surgery. The subjects are considered under the regional grouping,—the spine and the upper and lower extremities. The treatment of most of the orthopaedic and many of the traumatic cases necessarily includes the use of apparatus, and many kinds of apparatus are described and illustrated. The tendency to adhere to some of the older and well-established types is evident. This conservative attitude is most commendable.

As the author states in the preface, the book is not written for the experienced surgeon. It is intended for the younger surgeon and general practitioner, and to them it will be of great value.

Les tumeurs primitives du rachis. Chirurgie du corps vertébral. By J. Boudreaux. Paris, Vigot Frères, 1936. 45 francs.

The author calls attention to the fact that the primary tumors of the spine have always been regarded as rather unusual and have not received sufficient attention. The

work of Schlesinger, which appeared in 1898 and which marked an epoch in the understanding of vertebral tumors, served as a basis for subsequent studies which have demonstrated the importance of primary tumors. With the development of accurate facilities for investigation and study, it is now advisable to rearrange the grouping of the primary vertebral tumors with the special object of establishing identification by the evidence given by the x-ray and pathological anatomy. The author has found this task rather difficult because of the imperfect reports included in the literature of the earlier years.

In treating this subject, the author has divided the book into four parts. The first is a consideration of the malignant tumors, including myelomata, Ewing's sarcomata, osteosarcomata, chondrosarcomata, fibrosarcomata, and chordomata; the second is a discussion of benign tumors, among which are myeloplaxomata, angiomata, chondromata, osteomata, lipomata, fibromata, and solitary cysts; the third is devoted to diagnosis of the primary tumors; and the fourth is concerned with treatment.

Each group is carefully discussed with reference to the etiology, structural pathology, occurrence, growth, clinical characteristics, etc., and it is from this study that the author has made his classification of these primary tumors. Each type is illustrated by typical cases, and there are some excellent roentgenograms. It is to be regretted that the author has not more fully illustrated the different types of tumors, but those which are presented are very convincing.

The diagnosis of these primary tumors is discussed from the clinical and roentgenographic aspects and with relation to the primary and secondary occurrences and the malignancy and benignancy, and also with reference to the other pathological affections which are found in the spine. Diagnosis depends largely on the clinical and roentgenographic characteristics, and the author is evidently strongly in favor of exploratory biopsy as a routine supplementary procedure.

In the portion of the book which is devoted to treatment, the reader will find a great deal of suggestive information to aid in deciding upon and carrying out the method of treatment. The use and effect of radiotherapy on each group is given, as well as the results which may be expected from it. In the discussion of the surgery of these tumors, the various approaches to the different regions are very carefully described and the anatomy is illustrated by diagrams.

Handbook of Surgery. By Eric C. Mekie, M.B., Ch.B., F.R.C.S. (Edin.). With a Foreword by John Fraser, M.C., M.D., Ch.M., F.R.C.S.E. Baltimore, William Wood & Co., 1936. $4.50.

In the preface Mr. Mekie states that this book has been written primarily for undergraduates in an attempt to give them the irreducible minimum of surgical knowledge in order to pass the final examinations in surgery.

A glance through the table of contents and a rather careful reading of the chapters concerning bone and joint disabilities would suggest that the author has succeeded very well in his purpose. Each subject, although treated briefly, contains the essentials concerning the clinical features, course, and treatment. In a volume of this size it is, of course, impossible to give more than the barest outline of the multitude of surgical conditions now recognized. The reviewer feels that most students would be benefited more by a study of one of the larger text-books of surgery, even though they were unable to cover as much ground in the process. The mere reading of a compendium is usually not productive of a clear-cut conception of a disease process. Because of limitation of space presumably, there are very few illustrations and these are diagrammatic. As is usual in first editions, minor faults are frequently encountered which will doubtless be corrected in later editions.

It is rather evident that the volume is not for post-graduate use, at least primarily, and it is probably true that undergraduates in the United States will seek most of their information from American authors. The English undergraduate will probably find the volume of real service in preparation for his examinations.

ORTHOPÄDISCHE APPARATE UND BANDAGEN AUS KLINIK UND WERKSTATT (Orthopaedic Braces and Appliances from Clinic and Workshop). By Prof. Dr. Georg Hohmann. Beilageheft zur *Zeitschrift für orthopädische Chirurgie*, LXIV, 1936. Stuttgart, Ferdinand Enke, 1936. 7.50 marks.

The value of close cooperation between the orthopaedic surgeon and the brace-maker is beautifully illustrated by this monograph of seventy-two pages. Old principles are utilized in new ways to produce some valuable appliances. The description of Dr. Hohmann's hip splint for malum coxae, pseudarthrosis, and gluteal paralysis appeared in his previous writings. Now after he has supervised the construction of more than 150 of them, he presents the perfected splint in all of its various forms. The use of pressure by an adjustable lever in the correction of scoliosis and foot deformities, an adjustable strap to prevent hip flexion, and ingenious pressure pads are outstanding contributions. The contents will be valuable both to the orthopaedic surgeon and to the brace-maker.

THE TRUE PHYSICIAN. THE MODERN "DOCTOR OF THE OLD SCHOOL". By Wingate M. Johnson, M.D. New York, The Macmillan Co., 1936. $1.75.

This volume contains within a small compass a large amount of valuable and sagacious advice which an older physician might well give to his son or to any other young doctor about to enter the practice of medicine. It is evidently based on the author's experience as a modern doctor of the old school in North Carolina. Among the most interesting of its chapters are those on "Contacts with the Law" and "A Physician's Reading". Anyone might differ with the author in his selection of books, but the point of significance is the importance to every physician of literary contacts and background entirely apart from those of his own profession.

FRACTURES OF BONES AND THEIR TREATMENT. Edited by Prof. V. D. Chaklin. Sverdlovsk, The Ural Institute of Traumatology and Orthopaedics, 1935.

This book comprises 125 pages, and is written by several surgeons from the Ural Institute of Traumatology and Orthopaedics. A description of the simpler methods of treatment for closed fractures of the long bones and mandible is given. It is intended for the practising physician. It is unfortunate that the paper is of rather poor quality and the illustrations correspond to the quality of the paper. This book will be of interest to those American readers who would like to know how fractures are treated in an important industrial center in Soviet Russia.

CALIFORNIA MEDICAL ASSOCIATION CANCER COMMISSION COMMITTEE STUDIES. San Francisco, J. W. Stacey, Inc., 1936. 75 cents.

These studies have appeared separately in *California and Western Medicine* during the past five years and represent very careful investigations by the Committee. The latest opinions about the symptoms and onset, methods of diagnosis, and adequate treatment of early cancer have been collected from the members of the Association and, in many instances, from men outside the State. Emphasis has been laid on the need of cooperation between the surgeon and the radiologist in dealing with the cancer patient.

A Committee on Radiology has reported on the part played by the radiologist in each type of tumor treatment. The surgical treatment has been dealt with by committees on the following subdivisions: Gynecology; Breast; Skin and Mouth; Eye, Ear, Nose, and Throat; Genito-Urinary Tract; Chest; Bone; Connective Tissue and Leukemias; Central Nervous System; Gastro-Intestinal Tract; Thyroid; and Rectum, Anus, and Rectosigmoid.

Where there has been a great difference of opinion between various groups, both sides are presented. Finally, the appendix gives the results of questionnaires submitted to the world's leading cancer specialists on the best treatment of neck glands in cancer of the lip, tongue, and mouth.

PRINCIPLES AND PRACTICE OF RECREATIONAL THERAPY FOR THE MENTALLY ILL. By John Eisele Davis, B.A., M.A. New York, A. S. Barnes and Co., 1936. $3.00.

This monograph is intended as a practical manual for those concerned with the occupational or recreational treatment of various types of mental disorder. It has been prepared by the author in collaboration with Dr. William Rush Dunton, Jr., of the Johns Hopkins University, and has a foreword of introduction by Dr. Adolf Meyer.

The work is based on the authors' experience on the Veterans Administration Faculty at Perry Point, Maryland. After a discussion of types and disease entities, it presents the theory of education and reeducation as the basis of occupational treatment of the insane. It presents a classification of the various motor and psychic activities, the tests which may be applied in determining the value and guiding the application of a variety of formal and informal exercises, and finally it summarizes the aims and objectives of treatment. It has for some time been realized that occupational therapy provides perhaps the most valuable single agent in the palliation and, if possible, rehabilitation of the various mental deviations. This volume summarizes admirably the present status of our knowledge of this important subject and presents it with an explanation of its rational basis and sufficient detail of technical application to make it of value both to the occupational therapist and to the psychiatrist.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Anales (Valencia), III, Núms. 25, 26, 27, 1936.
Anales de Pediatría (Facultad de Medicina de Barcelona), II, Núm. 23, 1935.
Bollettino e Atti della Reale Accademia Medica di Roma, LXI, Fasc. 10–11, 1935.
Bulletin of the National Tuberculosis Association, XXII, Nos. 5, 6, 1936.
Cleveland Clinic Quarterly, III, No. 2, 1936.
Journal of the Indian Medical Association (Calcutta), V, Nos. 7, 8, 1936.
Journal of South Indian Medicine (Madras), II, Nos. 5, 6, 1935.
University of Pennsylvania, Graduate School of Medicine, Announcement for 1936–1937. Philadelphia, 1936.
The Quarterly Bulletin of Sea View Hospital (New York), I, No. 3, 1936.

DIE OPERATIVE BEHANDLUNG DER HABITUELLEN UND PERMANENTEN LUXATIO PATELLAE, IM BESONDEREN NACH KROGIUS UND GOLDTHWAIT (The Operative Treatment of Recurrent and Chronic Dislocation of the Patella, Particularly with Especial Reference to the Operations of Krogius and Goldthwait). O. Kapel. *Acta Chirurg. Scandinavica*, LXXVII, 201, 1935.

WEITERE UNTERSUCHUNGEN ÜBER LUXATIO PATELLAE (Further Studies of Dislocation of the Patella). O. Kapel. *Acta Chirurg. Scandinavica*, LXXVII, 296, 1935.

Follow-up examinations were made on thirty-three patients with forty-two knees upon which operations had been performed. In four unilateral cases the dislocations were chronic. After a variety of operations three of these were cured. One of these cases, that of a congenital dislocation, recurred at once after a Hübscher-Krogius operation. The writer advises against operation in the chronic case if the symptoms are not distressing.

Of the twenty-nine patients upon whom thirty-eight operations for recurrent dislocation of the patella had been performed, four were operated on by a variety of methods with one failure and one fair result. Thirty-four operations were performed as follows: twelve by the Krogius technique; twelve by a combination of the methods of Krogius and Goldthwait; and ten by capsulorrhaphy combined with the technique of Goldthwait.

The cases are reported in detail with the late results. In the ten cases in which the Goldthwait technique was used alone, there were six cures and four failures. The other twenty-four cases, operated upon by the Krogius or combined methods, included one

immediate failure and one poor result without actual redislocation. The other results were good and these two methods are highly recommended.

In a group of fifty-five traumatic dislocations collected from histories in the Copenhagen hospitals, 50 per cent. of the cases were followed by habitual recurrences and 25 per cent. by other difficulties; only 25 per cent. of the patients were without complaint. A complete tear of capsule and synovia was found in three cases operated upon soon after traumatic dislocation. The writer advises primary suture to avoid recurrences. The mechanism of causation is discussed.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Four Cases of Ewing Sarcoma in Ribs. Hilding Bergstrand. *Am. J. Cancer,* XXVII, 26, May 1936.

The author is convinced that Ewing's sarcoma of the rib is not extremely rare. He reports four cases, all occurring at about the age of puberty. The tumors originated in the sixth and eighth ribs in the back, and tended to grow into the pleural cavity, pushing the pleura ahead of them. They were coarsely lobulated tumors with their greatest length along the ribs. The roentgenograms showed a characteristic increase in density and volume of the ribs, with spicule formation. One of the patients, treated by operation and x-ray, is apparently free from disease over five years after operation, although pulmonary metastases were observed two years after operation. The author points out that this tumor occurs in those parts of the skeleton in which ossification begins toward the end of the second month of foetal life, and suggests that they may derive from the blastema cells of the mesenchyma.

The paper is illustrated with roentgenograms and photomicrographs, and reviews briefly the literature on the histogenesis of these tumors.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Liposarcoma of Bone. Donald J. Rehbock and Harry Hauser. *Am. J. Cancer,* XXVII, 37, May 1936.

The authors report two cases of this rare tumor, both of which occurred in elderly patients,—in one instance in the femur and in the other in the ilium. Slow growth and a tendency to develop bone and lymph-node metastases distinguish the tumors from other kinds of primary bone tumor. In one patient there appeared to be definite regression of a bone metastasis in response to x-ray therapy.

The paper is illustrated with photomicrographs and roentgenograms.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Bone Changes of Leukaemia in Children. James M. Baty and Edward C. Vogt. *Am. J. Roentgenol.,* XXXIV, 310, 1935.

The authors state that in most cases of leukaemia the diagnosis is relatively simple, but occasionally the symptoms are atypical and there may be considerable diagnostic difficulty. Aleukaemic leukaemia presents the greatest difficulty. Roentgenographic examination of the skeleton may be helpful in arriving at a correct diagnosis.

During the past six years in sixty cases of leukaemia roentgenograms were made of part or all of the skeleton in forty-three. The discussion is based on the roentgenographic findings.

The most frequent change was the presence of a narrow transverse zone of diminished density just proximal to the metaphysis of the long bones. This zone varied from two to five millimeters in width and was most marked in bones where the growth is rapid. This line was seen in bones of 70 per cent. of the total number of cases. It was present in 80 per cent. of the cases of myeloid leukaemia and in 65 per cent. of the cases of lymphoid leukaemia.—*T. L. Waring, M.D., Iowa City, Iowa.*

WIRBELBRÜCHE UND WIRBELVERRENKUNGEN; BOGENBRÜCHE VOM TYPUS DER SPONDYLOLYSE UND DER SPONDYLOLISTHESE UND IHRE BEDEUTUNG FÜR DIE ERHALTUNG DES RÜCKENMARKES (Fractures of the Vertebral Arches of the Spondylolystic and Spondylolisthetic Types and Their Significance in the Preservation of the Spinal Medulla). L. Böhler. *Chirurg*, VII, 477, 1935.

Most of the German authors believe that spondylolysis or spondylolisthesis always develops on a congenital basis. Most of the American authors explain it as a traumatic lesion. Meyer-Burgdorff thinks the disease is due to a traumatic gibbus with marked lordosis where, by overexertion of the interarticular portion of the fifth lumbar vertebra, a fracture gradually develops leading to spondylolysis. However, Meyer-Burgdorff does not believe that the interarticular portions can be fractured by a single sudden trauma, as they are very strong.

Böhler states that up to the present time there has never been published a series of roentgenograms proving the gradual development of this gliding process. He believes also that besides the spondylolisthesis which develops by itself there exist certain cases in which it is caused by a single sudden trauma. In roentgenograms of patients, as well as in autopsies of recent fractures of the vertebrae, Böhler found fractures of the interarticular portions, with or without gliding, alternating in all vertebrae with the exception of the first, third, fourth, and fifth vertebrae. This is explained by the following fact: In all other vertebrae the interarticular portions are the thinnest parts of the vertebral arches. In the first, third, fourth, and fifth cervical vertebrae, however, the articular processes are perpendicularly posted over each other and the parts between them are especially strong.

The mechanism leading to this fracture is a traumatic effect coming obliquely from backward and above in the direction toward an intervertebral disc. In this case the whole traumatic effect concentrates on the interarticular portion. This becomes fractured and the intervertebral disc is torn, which leads to the gliding of the vertebra. This form of a pure luxation fracture of the real spondylolisthetic type is found in the lumbar vertebrae only. In the upper portion of the spinal column this fracture is generally caused by hyperflexion and a simultaneous shearing effect coming from back and above. In this portion the injury involves a compression of the vertebra with gliding of the vertebra above and a fracture of the intervertebral portions either of the dislocated vertebra or of the one above. If the trauma does not come from the back only, but also from one side, a fracture of only one of the interarticular portions may occur.

In fractures of the lower cervical spine the fracture of the interarticular portion always occurs in the gliding and not in the fractured vertebra. In the case of the second cervical vertebra the fracture mechanism is mostly a hyperextension and here it is very characteristic that from one to two millimeters of the joint surfaces of the superior articular processes remain in connection with the posterior parts of the arches. In the lumbar spine hyperextension is quite frequently the cause of a fracture of the interarticular portion.

The author states that the opinion is quite frequently expressed that the fractures of the arches are the most dangerous, as they develop by a direct trauma to the spinous processes, and the broken arch may by continuation of the trauma be pressed into the spinal medulla. He does not agree with this opinion, as he never saw a fracture of this kind. He believes that it is possible that a direct trauma to the spinous processes may lead to a fracture of the arch and a lesion of the medulla when the fracture occurs not in the intervertebral portions, but in the inferior articular processes. However these cases are rare.

In all fractures of the arches, roentgenograms, as well as autopsies, show that the posterior part of the fractured arch, together with the spinous process, remains posterior to the whole ligamentous apparatus and is kept behind by the inferior articular processes. The corresponding vertebral body, together with the anterior part of the arch, glides forward. Therefore, at the fracture level there is always a widening of the spinal canal and, if the dislocation of the superior part of the spinal column is not too extensive, the

medulla may remain unchanged. In luxations with anterior fractures, however, a narrowing of the spinal canal with compression of the spinal medulla always results. The author concludes, therefore, that fractures of the arches do not as a rule destroy the spinal cord but save it.

Sometimes complete paralysis is found after severe trauma to the cervical spine without any signs of a fracture or luxation of the cervical spine in the roentgenogram. In those cases the sudden severe trauma produces a momentary total luxation of the cervical spine with compression of the medulla, resulting in paralysis. The luxation, however, is immediately spontaneously reduced. There is only a slight sign visible in the roentgenogram,—*i.e.*, the decrease in the height of the intervertebral disc which was torn at the time of luxation.—*Traute Pich, M.D., Iowa City, Iowa.*

KNOCHENCYSTE BEI ENCHONDROM DES FEMUR. RESEKTIONS-PLASTIK. (Bone Cyst in Enchondroma of the Femur. Plastic Resection.) E. Looser. *Deutsche Ztschr. f. Chir.*, CCXLIV, 321, 1935.

The first explanation of the occurrence of bone cysts was given by Virchow, who found cartilaginous tissue in the neighborhood of a cyst in the humerus. Later, however, Virchow's conception was entirely abandoned. Looser has observed a case which proves that Virchow's idea is correct, at least in a small number of cases.

The patient, a male, now nineteen years old, had had a left-sided limp of many years' duration, with weakness of the left leg. The family history was negative. At the age of eleven, a roentgenogram had been taken which showed an irregular bony structure in the proximal end of the femoral diaphysis. Tuberculosis was suspected. Heliotherapy was instituted for a few weeks. One year later, the patient suffered a fracture of the femur while skiing. A roentgenogram showed a pathological fracture through a bone cyst. This fracture healed within ten weeks without shortening. One year later, an incision was made in the cyst wall, and the pathological report was ostitis fibrosa cystica (some islands of cartilage were found in the section). Three years later, the patient was admitted again with pain in the thigh, following forceful strain of the hip region. The roentgenogram showed the bone cyst still present. With the electric saw, a slice of bone, fourteen and one-tenth centimeters long, was removed. A multilocular cystic lesion was encountered, which was surrounded in part by bony tissue and in part by cartilaginous tissue. Half a year later, a fracture occurred through the cystic area. At operation, the upper half of the femur was resected and a tibial bone graft (twenty-three centimeters long, two centimeters wide, and one centimeter thick) was implanted. Solid union had occurred eight months following the operation. One inch of shortening is present, but the patient has good use of the extremity.—*Ernst Freund, M.D., Venice, Florida.*

ÜBER DIE SPONDYLOLISTHESIS. W. Jaeger. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, LII, 107, 1935.

Three factors are of importance for the establishment of a spondylolisthesis: (1) obliquity of the gliding surfaces; (2) separation of the gliding vertebra from its supporting surface, which means a destruction of the caudal intervertebral disc; and (3) changes in the interarticular portion. The term "prespondylolisthesis" should be discarded because it refers only to the first factor and neglects the two others. In some cases, it is all right to speak with Scherb of a "sacrum arcuatum" and "sacrum acutum". If all three factors are demonstrable, but slipping has not yet occurred, one may call the condition "spondylolisthesis imminens".

Jaeger examined 244 spines and found eleven cases of spondylolisthesis and five of spondylolysis. Among these cases were sixty-four certain and eight doubtful fractures of the vertebral bodies, which means that there is one case of spondylolisthesis to every sixteen cases of fracture of the body. Meyer-Burgdorff, therefore, is correct in his statement that spondylolisthesis is frequently associated with pathological conditions at higher levels of the vertebral spine.—*Ernst Freund, M.D., Venice, Florida.*

LATE RESULTS OF THE OPERATIVE TREATMENT OF OSTEO-ARTHRITIS OF THE HIP-JOINT. C. Max Page. *Lancet*, I, 1313, 1935.

After analyzing 112 cases in which operations had been performed during the past five years, the author concludes that of the two procedures—arthrodesis or arthroplasty of the hip joint—arthrodesis gives the best late results. He states that in regard to arthrodesis better technique does give better results; however, the most ingenious arthroplastic procedures may result in a stiff hip while a rough reconstruction operation may produce a freely movable hip. The vascular supply of the parts seems to the author to be the important determining factor.

Of the sixty-nine cases in which arthrodeses were performed, the author reports good results in 70 per cent., moderate results in 17.4 per cent., and bad results in 11.6 per cent. Of the nineteen cases in which arthroplasties were done, good results were obtained in 37 per cent., moderate results in 31 per cent., and poor results in 31 per cent.

The operative procedures used for fusion were resection of part of the head of the femur and resection of part of the acetabulum. An iliac graft was occasionally used. For arthroplasties, the Whitman operation was employed.—*Lewis Cozen, M.D., Iowa City, Iowa.*

BONE CHANGES SIMULATING TUBERCULOSIS OR TUMOUR, WITH SPECIAL REFERENCE TO OSTEOCHONDRITIS. James F. Brailsford. *Lancet*, I, 1487, 1935.

The author discusses the correlation of roentgenographic findings with clinical observations in diseases of bone.

Among the common sources of error, the author includes the mistaking of ossifying periosteal hematomata for periosteal sarcomata. Hematomata, located in the shaft of a metatarsal, may come from very slight trauma. In a few weeks the dorsum of the foot becomes swollen and reddened, and a hard tumor may be palpated. Roentgenographic examination may show a flocculent deposit of calcium around the metatarsal, which has relative osteoporosis. These findings have been known to lead to amputation. If put to rest, the clinical signs disappear and the calcium deposit molds itself around the metatarsal.

In bone tuberculosis, serial roentgenograms are invaluable for watching the progress of the lesion and assisting in the treatment.

Legg-Perthes disease is discussed in relation to the roentgenographic changes. The earliest evidences are (1) an increase in the density of the femoral capital epiphysis; (2) a relative increase in the joint space (as compared with the opposite hip); and (3) osteoporosis of the adjacent extremity of the diaphysis. These changes are found about two months after the onset of symptoms. The dense epiphysis then begins to show signs of compression fracture, followed by the appearance of fragmentation, and the epiphysis is compressed and flattened still more. There is gradual absorption of the dense islands of bone and compression and expansion of the proximal end of the diaphysis. The signs of compression fracture and flattening of the epiphysis are found during the first eighteen months of the disease. After that roentgenograms show a joint outline of a regenerated epiphysis in which the dense fragments are absorbed. Eventually, the last dense nucleus is absorbed and the extremity of the diaphysis shows increased calcium and obliteration of the osteoporotic zone. Signs of regenerated epiphysis and increased calcium in the diaphysis occur during eighteen months to four years after onset and, while these signs are present, the epiphysis remains plastic and can be deformed by pressure; hence the occurrence of permanent deformities if the epiphysis is not protected from the strain of weight-bearing. After four years, the cancellous epiphysis assumes the roentgenographic appearance of normal bone. Although the epiphysis and adjacent diaphysis are compressed, the growth cartilage does not disappear as in an inflammatory process. This is the argument against sepsis or displaced epiphysis as a causative factor. All changes take place within the capsule,—there is apparently an early increase in synovial fluid and a redistribution of calcium in the areas associated with the fluid contents of the

capsule. At first, the epiphysis takes up calcium while the end of the diaphysis loses it; later, in healing, the flow of calcium is in the opposite direction. *In contrast to tuberculous arthritis, the healed articular surfaces are smooth, though deformed, and bony ankylosis does not occur because the articular cartilage is not destroyed.*

The later development of arthritis, with changes in the acetabulum and head of the femur, is discussed. Statistically, *the disease is three times more frequent in males*, both sides are about equally affected, and the condition starts commonly between the ages of four and eight years. Clinically, the most common sign is a limp with pain in about 30 per cent. of the cases. *Periodic roentgenograms show that the bone remains plastic for an average of over three years.* The best results are obtained by early recognition of the disease and immobilization of the femur as long as the head is plastic, even up to four years. *Differential diagnosis lies between Perthes' disease and (1) tuberculosis, (2) septic arthritis, (3) endocrine disorders (hypothyroidism), and (4) chondrodystrophies.*

The next discussion is Preisser's disease of the carpal scaphoid. This comes on after injury, *frequently following the use of a compressed-air drill. There is swelling and tenderness over the scaphoid with stiffness of the wrist.* Roentgenograms may be negative, but should be taken in ulnar deviation or with the back of the hand on the film, the skin over the scaphoid being the area of closest contact. *Frequently fine fissures are thus seen.* Pain subsides after a few weeks, except on extreme hyperextension. Another injury, which may be very slight, brings a recurrence of severe pain and stiffness. Roentgenograms will reveal a cystlike area in the scaphoid with a fissure line through it, or there may be several such areas.

Finally, the author discusses osteochondritis dissecans, a name coined by König. It is found generally between the ages of sixteen and twenty-five and is more common in males. The etiological theory of aseptic necrosis is mentioned, with some thought being given to trauma and subsequent local vascular disturbance of the fragment. Occasionally a surgeon will miss the loose body because it is covered by intact cartilage, which substantiates the idea that the condition is due to a sequestration of a small fragment of subchondral bone. The typical roentgenographic appearance of the lateral surface of the medial condyle of the femur is described.—*Lewis Cozen, M.D., Iowa City, Iowa.*

GOLD TREATMENT OF RHEUMATOID ARTHRITIS. S. J. Hartfall and H. G. Garland. *Lancet*, II, 8, 1935.

The authors report 100 cases which were treated for two years by this method. They obtained excellent results, as evidenced by symptomatic improvement and objective signs, in 70 per cent. of the cases and some improvement in 90 per cent. of the cases. Three deaths occurred, two of which were directly caused by the gold therapy. Crisalbine and gold sodium thiosulphate were injected intravenously in doses of five-hundredths to two-tenths grams weekly until two grams were given. Depending on the progress of the case, two to three or more courses were given, with an interval of at least six weeks between courses.—*Lewis Cozen, M.D., Iowa City, Iowa.*

SOBRE UNA RARA ANOMALÍA VERTEBRAL CONGÉNITA. EL TELESCOPAGE VERTEBRAL. SU DIAGNÓSTICO DIFERENCIAL. (A Rare Congenital Anomaly. Telescoped Vertebra. Its Differential Diagnosis.) José Roberto Abdala. *Prensa méd. Argentina*, XXII, 1807, 1935.

Monstrocities have been studied by pathologists and anatomists, but, because they were considered incompatible with life, the clinician has paid little attention to them. The x-ray, however, introduced a new method of study and many similar lesions which, in the severe form, produced monsters can now be traced, in lesser degrees, in the living.

In 1912 and 1919 Klippel and Feil published their description of the congenital reduction in number and fusion of cervical vertebrae. The term "vertebral telescopage" was suggested by Bar in 1903 to describe what he thought happened in foetal life,—a telescoping of the vertebrae by some traumatic action. The infant whose case he re-

ported apparently had no neck; the ears appeared lower than normal, the trunk shortened. Roentgenographic examination showed the lower cervical vertebrae reduced to small osseous nodules fused together. Anomalies of the ribs were also present.

The author believes that the term "Klippel-Feil syndrome" should be used only for the short neck due to reduction in number of the cervical vertebrae.

The various theories of pathogenesis are discussed. Emotional shock, self-attempted abortions, chemicals, toxins, and infections are among the possible etiological factors. Inasmuch as the centers of ossification of cervical vertebrae do not appear until the third to fourth month, while those below begin in forty to fifty days, this would explain why severe trauma, such as violent uterine contractions produced by attempts to produce abortion, would cause a collapse of the lower cervical vertebrae.—*G. Mosser Taylor, M.D., Iowa City, Iowa.*

OSTÉITE FIBREUSE DÉFORMANTE DE PAGET ET SARCOME (Osteitis Deformans and Sarcoma). P. Banzet, J. Delarue, and A. Elbim. *Presse Méd.*, XLIII, 1842, 1935.

On the basis of a case which they observed in which sarcoma developed in a patient suffering from Paget's disease, the authors review some of the literature on this subject. They call attention to the fact that true sarcomata are apparently rare. They point out that some confusion may have arisen from the fact that the "brown tumors", which consist of myeloplaxes and which form part of the histological picture of von Recklinghausen's fibrocystic osteodystrophy, have been mistaken for true sarcomata. They do not believe that the tissue degenerates into sarcoma, but that a sarcoma develops as a true new growth in a bone already the site of the changes characteristic of Paget's disease. They note the greater tendency toward fracture in cases of sarcoma as compared with the uncomplicated cases of Paget's disease.—*Henry Milch, M.D., New York, N. Y.*

LE "FORAGE MÉDICAL" DE LA HANCHE ("Medical Forage" in the Treatment of Arthritis of the Hip). F. Coste and J. Fauvet. *Presse Méd.*, XLIII, 2002, 1935.

Since the action of surgical drilling of the neck of the femur is to increase the blood supply of the arthritic hip, the authors use the term "medical forage" in the sense that it produces an increase in the blood supply by medical means. The procedure which they describe consists in the periarticular injection of histamine bihydrochlorate. The injection is begun with a dosage of one-half a milligram to one milligram. Further details of the treatment are not given.

The authors report twelve cases in which an average of six injections seem to have yielded marked amelioration of the pain. However, they note eight other cases, apparently similar to the first twelve, in which the results were not satisfactory. They cannot account for the variation in the results. They suggest that the method be given trial because one can tell after one or two injections whether there is any possibility of success. Where there is no immediate response, the method should be discontinued.—*Henry Milch, M.D., New York, N. Y.*

OSTÉITE DÉFORMANTE DE PAGET ET TRAUMATISME (Paget's Osteitis Deformans and Trauma). J. A. Lièvre. *Presse Méd.*, XLIV, 45, Jan. 8, 1936.

The author reports three cases and calls attention to the literature on the subject of localized Paget's disease. He notes that, while other bones—*e.g.*, the femur—may be attacked, the tibia is most commonly the site of the localized Paget's disease. The disease usually begins after an injury and is characterized by a latent interval between the injury and the onset of symptoms. Clinically, roentgenographically, and pathologically, the specimens resemble those seen in the diffuse type of Paget's disease.—*Henry Milch, M.D., New York, N. Y.*

A propos du traitement de l'épicondylite des joueurs de tennis (Treatment of the Epicondylitis of Tennis Players). L. Tavernier. *Presse Méd.*, XLIV, 99, Jan. 15, 1936.

With reference to Massart's suggestion for the local injection of novocain in the treatment of epicondylitis, Tavernier states that his results from this method have been completely unsatisfactory. In his opinion, mere scraping of the epicondyle with detachment of the muscles is a simple and safe procedure.—*Henry Milch, M.D., New York, N. Y.*

A propos du traitement par infiltration novocaïnique de l'épicondylite des joueurs de tennis, des maladies post-traumatiques de même ordre, des soi-disant apophysites de croissance, de certaines fractures sans déplacement et des séquelles ostéo-articulaires (Treatment by Novocain Infiltration of the Epicondylitis of Tennis Players, of Post-Traumatic Disorders of the Same Type, of the So Called Apophysitis of Growth, of Certain Fractures without Displacement, and of Osteo-Articular Sequelae). René Leriche. *Presse Méd.*, XLIV, 99, Jan. 15, 1936.

Leriche disagrees with Tavernier and is in complete accord with Massart in the treatment of epicondylitis. He goes even farther and states that novocain infiltration is of great value in treating all post-traumatic juxta-epiphyseal pain. This method should be used in the treatment of epiphysitis during growth, in the foot, the hand, the elbow, and the shoulder, and in the treatment of all sequelae of articular fractures.—*Henry Milch, M.D., New York, N. Y.*

Apropos de traitement des fractures des condyles maxillaires (Treatment of Maxillary Condyles). L. Lebourg. *Presse Méd.*, XLIV, 360, March 4, 1936.

Fracture of the condylar neck of the maxilla in the adult is usually best treated by immobilization. In the younger subject immobilization may be dangerous in that it may lead to ankylosis of the jaw. To prevent this, the author recommends the application of elastic traction. This permits adequate alignment of the fragments and, while maintaining reduction, allows motion of the mandible.

Traction is applied by means of rubber bands fixed to the canine teeth and to a resistant wire which is so placed as to form a perifacial arc about one inch distant from the arch of the mandible. The ends are fixed to a plaster fillet which encircles the forehead. This permits downward and forward traction of the large mandibular fragment and makes arthrotomy for the small condylar fragment unnecessary.—*Henry Milch, M.D., New York, N. Y.*

Nodules sous-cutanés chez les rhumatisants chroniques. Lipomatose nodulaire. (Subcutaneous Nodules in Chronic Rheumatic Patients. Nodular Lipomatosis.) Pr. Merklen, R. Waitz, and J. Warter. *Presse Méd.*, XLIV, 473, March 21, 1936.

The authors note that true rheumatic subcutaneous nodules are to be distinguished from a nodular lipomatosis. They report three cases in which patients suffering from a chronic rheumatic condition were affected with histologically established diffuse nodular lipomatosis. These nodules are differentiated from the rheumatic nodules by the facts that they are located at some distance from the joints, they are painful to the touch, and histologically they are true encapsulated lipomata and not degenerated rheumatic nodules.—*Henry Milch, M.D., New York, N. Y.*

RARÉFACTION OSSEUSE POST-TRAUMATIQUE (Post-Traumatic Rarefaction of Bone). Jean Baumgartner and Francis Berthoud. *Presse Méd.*, XLIV, 495, March 21, 1936.

Attention is called to the fact that, since the work of Leriche, the osseous system has come to be considered as a large reservoir of readily mobilizable calcium. Osteoporosis, the evidence of this mobilization of calcium, is the result of a prolonged hyperaemia, due to vasomotor imbalance which may be caused by traumatism or infection. The exact mechanism of the prolonged action of trauma has not been explained, except upon the basis of a vasomotor instability. In this connection, the authors report the case of a young woman who had been subjected to bilateral oophorectomy eight years before the onset of trouble in the ankle and knee joints. The roentgenograms, which were examined by Leriche himself, suggested a post-traumatic osteoporosis with fracture. In view of the earlier operative intervention, homovarine (Byla) and tricalcine were given hypodermically daily, and later at longer intervals, for a period of three months. The disappearance of the lacunar defects under this therapy led the authors to the opinion that trauma plays a secondary or precipitating rôle in the development of osteoporosis, while the primary rôle is taken by some endocrine disturbance. They call attention to a communication by Leriche, who suggested injections of ovarian extract in the treatment of traumatic osteoporosis of the knee.—*Henry Milch, M.D., New York, N. Y.*

INJECTIONS INTRA-ARTÉRIELLES D'ANTISEPTIQUES DANS LES INFECTIONS DES MEMBRES (Intra-Arterial Antiseptic Injections in Infections of the Extremities). G. Arnulf and Ph. Frieh. *Presse Méd.*, XLIV, 629, Apr. 15, 1936.

The authors call attention to the fact that intra-arterial injections are indicated in severe lymphangitis, wet gangrene of the extremities (especially of arthritics), suppurative arthritides (including the gonorrhoeal variety), suppuration of the extremities (including abscess, osteomyelitis, etc.), gas gangrene, and tropical ulcers. For the most part, the results are only moderately successful in any condition except the lymphangitides in which they are particularly satisfactory.

The authors especially point out that the intravenous method is not to be used except as recommended by Leriche in cases of staphylococcus infection where gentian violet appears to have specific effect. Otherwise, a 2-per-cent. aqueous solution of mercurochrome is injected into the artery. The artery may be punctured subcutaneously by a spinal-puncture needle, eight centimeters long, with a short, sharp bevel, or it may be exposed by incision and then punctured. Eight to ten cubic centimeters of solution is injected,—never more, since larger amounts may result in liver and kidney disturbances. Occasionally two, three, or four injections may be undertaken. The indication of a satisfactory injection is the discoloration of the skin and a thermal rise on the day following the injection. The contra-indications are age, albuminuria, and vasomotor disturbances of the extremities. For the lower extremity, the injection is made into the femoral artery; for the upper extremity, into the subclavian artery or into the brachial artery at the elbow.

The authors enumerate some fourteen cases in which this therapy was undertaken with improvement. When the improvement is noted, it is apparent after one or, at most, two injections. If no improvement is noted, the usual surgical procedures are to be undertaken.—*Henry Milch, M.D., New York, N. Y.*

LA RÉDUCTION DES FRACTURES DU COTYLE AVEC PÉNÉTRATION INTRA-PELVIENNE DE LA TÊTE FÉMORALE (Reduction of Central Fractures of the Acetabulum with Intrapelvic Penetration of the Femoral Head). P. Moiroud. *Presse Méd.*, XLIV, 748, May 6, 1936.

Apart from the question of reduction by means of traction in the axis of the shaft of the femur and in the axis of the neck of the femur, the author calls attention to the prognosis of such injuries. Even when the fracture was properly reduced, Cottalorda in 1922

noted ankylosis following this injury in about 40 per cent. of the cases. Where this does not occur, there may be limitation in function due to the fact that the head of the femur seems to atrophy, not only in consequence of the injury, but also as a result of trophic disturbances. Therefore, the question of therapeutic fusion of the hip should be considered in all cases of this type of injury.—*Henry Milch, M.D., New York, N. Y.*

THE INFLUENCE OF THE THYROID GLAND ON THE NATURE OF BONE CALLUS. I. A. Shtshervina. *Soviet Surg.*, X, 29, 1935.

A series of experiments on rats were undertaken with the purpose of establishing the influence of the thyroid-gland secretion on the physical properties of callus. The resistance to tension, strain, and compression was investigated. The following were the conclusions reached:

The removal of the thyroid gland retards regeneration of bone. Newly formed bone is less resistant. Transplantation of the thyroid gland shortens the time of regeneration and makes the regenerated bone more resistant, approaching the strength of bone in control animals. The transplantation of the thyroid gland with a simultaneous transplantation of cartilage under the skin produces a callus equal in strength to, and even surpassing, callus in control animals. These results require further clinical investigations.—*Emanuel Kaplan, M.D., New York, N. Y.*

NEW METHODS OF LEG AMPUTATION. G. A. Reinberg and A. V. Kaplan. *Soviet Surg.*, XII, 65, 1935.

To avoid the usual postoperative complications of leg amputation a new method is suggested. Based on cadaver study, it gave apparently satisfactory results in nineteen cases in which operations were performed by seven surgeons.

An anterior skin flap is dissected out, its base being wider than the half of the circumference of the leg and its length more than the diameter of the leg. A horizontal skin incision unites the proximal ends of the flap posteriorly. The skin in the back is separated from the soleus. The Achilles tendon is cut from above downward and from the back forward. The triceps surae is separated from the bones of the leg to the level of amputation. The bones are sawed through and smoothed out. Two flaps are thus formed: an anterior skin flap and a posterior musculo-aponeurotic flap. The muscular flap is united to the periosteum of the tibia in front, and the skin flap is attached to the skin of the back of the leg.—*Emanuel Kaplan, M.D., New York, N. Y.*

INJURIES TO THE CRUCIAL LIGAMENTS OF THE KNEE JOINT. Henry Milch. *Soviet Surg.*, X, 101, 1935.

After a thorough analysis of the physiology of knee motion and the rôle played by the crucial ligaments in this motion, the author gives a historical description of the surgical treatment of injuries to the crucial ligaments and a critical analysis of these operations. Citing examples from an extensive literature and basing his conclusions on his personal experience, the author finds that the importance of the crucial injuries is exaggerated, and that the chief offender in the loss of stability in knee injuries is the medial collateral ligament. The presence of an extensive tear of the crucial ligaments does not require their surgical restoration. The repair of the medial collateral ligament, which may be torn in early cases or weakened in old cases, is all important. The repair is accomplished by a restoration of this ligament with a fascia-lata transplant.—*Emanuel Kaplan, M.D., New York, N. Y.*

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TREATMENT OF BENIGN GIANT-CELL TUMORS *

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To the orthopaedic surgeon it is obvious that there exists a considerable difference of opinion among those who have had the opportunity to gain experience in the treatment of bone tumors in medical centers where clinician, roentgenologist, pathologist, and surgeon cooperate in their efforts to produce better results. The scientific evaluation of any treatment demands correct diagnosis, skill, and judgment in the selection and management of the method employed and a careful follow-up record over a period of years. Too often a method has become discredited because it was assumed to have been the procedure of choice when, in reality, the diagnosis was based on insufficient evidence and the subsequent course proved the error.

There is opportunity for the display of considerable judgment in the selection of the most efficient method to be employed in the treatment of benign and malignant bone tumors, especially of the rarely encountered giant-cell tumors which at times present such a clinical enigma that they challenge the physician's ability to cope with them. The site and the size of the tumor, the perforation or the non-perforation of the bony shell, the penetration of the soft tissues, and the rapidity of growth are important factors in determining the method of treatment to be employed.

As giant-cell tumors were formerly considered to be malignant and were classified with sarcomata of bone, the treatment was radical and amputation was commonly practised. As knowledge of the pathology of bone advanced, the benign nature of such giant-cell tumors was recognized and treatment became less radical, the accepted method of treatment being curettage followed by chemical or thermal cauterization. Some of these tumors were found to recur and repeated surgical treatment was necessary before cure was effected; others were found to metastasize.

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 21, 1936.

The supposed transition from benignancy to malignancy was ascribed to meddlesome surgery. There then arose a group of roentgenologists who advocated irradiation to the exclusion of all other forms of treatment, and some convincing cases of apparent cure were reported after surgical treatment of various types had failed. Other roentgenologists reported failures from the use of irradiation. Therefore, both successes and failures were attributed to surgery and to irradiation individually, and accordingly combinations of both methods were employed. The results improved, but unfortunately in some instances either form of treatment or a combination of both resulted in sufficient damage to the tissues to make amputation inevitable. Too often a good surgeon is led astray by the incorrect interpretation of roentgenograms or microscopic sections.

The author prefers to use the terms "benign giant-cell tumors" and "malignant giant-cell sarcomata", and this paper will be confined to the former group. Pathologists have been able to differentiate these two variants and the writer believes they should both be included in the classification of the Registry of Bone Sarcoma. However, it appears impossible at present to differentiate microscopically giant-cell-tumor tissue found in cases of osteitis fibrosa cystica from the generalized skeletal lesions found in cases of parathyroid tumor with hyperparathyroidism. Values for calcium greater than twelve milligrams, for phosphorus less than three milligrams, and for phosphatase greater than five units per 100 cubic centimeters of blood are important factors in the differential diagnosis. Although there may be a relationship between such lesions and benign giant-cell tumor, they have been excluded from the present investigation. To the practical surgeon this differentiation is important, for delay is dangerous. Since he cannot differentiate the benign and the malignant forms, he obtains consent for the type of operation which in his judgment is indicated as the best way of eradicating the tumor. The surgical pathologist, however, may often be of great aid in determining whether the growth is benign or malignant before the operation is completed. Were it possible to give every patient who complains of swelling or pain the benefit of early and expert service of a roentgenologist, the presence of tumors would be discovered in time to make treatment more efficient and the prognosis better. Surgeons are too often consulted only after the destructive changes have become so extensive that surgical intervention of a conservative type is of questionable value. The conscientious surgeon realizes that biopsy is justified only in cases of tumor of an unusual clinical and roentgenographic character and that most tumors may be diagnosed roentgenographically. He also appreciates the fact that certain kinds of tumor respond to such an extent as to make diagnostic irradiation possible and that no one treatment is infallible. Accordingly he confers with his associates so that he may give the patient the most efficient care.

Simmons observed that 7.5 per cent. of giant-cell tumors which had been treated conservatively were later found to be malignant and to have

TABLE I

SEX AND AGE INCIDENCE

Sex	No. of Patients	Per Cent.
Males	26	42.6
Females	35	57.4
Total	61	100.0

Age	Youngest (*Years*)	Oldest (*Years*)	Average (*Years*)
Males	12	60	27.9
Females	13	48	27.9

Age by Decades	Males	Females	Total	Per Cent.
10 to 19	9	7	16	26.2
20 to 29	6	15	21	34.4
30 to 39	7	7	14	23.0
40 to 49	1	6	7	11.5
50 to 59	2	0	2	3.3
60 to 64	1	0	1	1.6
Total	26	35	61	100.0

produced pulmonary metastasis. Coley reported fifty cases in which giant-cell tumors were diagnosed as benign, but in which ten patients died of metastasis. MacGuire and McWhorter reported twenty cases, in four of which the tumors proved to be malignant later on. Finch and Gleave, Chatterton and Flagstad, and Sosman, Dyke, and Orr have referred to similar cases. In the present series of cases one (1.5 per cent.) of the patients was later found to have microscopic evidence of osteogenic sarcoma, but the pathologist checked the slides and verified the original diagnosis of benign giant-cell tumor. Coley obtained varied diagnoses in submitting the same tissue to different pathologists, and, although he was of the opinion that the majority of giant-cell tumors could be diagnosed by clinical and roentgenographic examination, 20 per cent. required microscopic interpretation. Bloodgood, out of a total of 177 cases collected from the Registry of Bone Sarcoma together with some of his own, found no evidence of metastasis of giant-cell tumors. Both Simmons and Kolodny, after reviewing cases in the Registry of Bone Sarcoma, reported similar findings.

Primary irradiation of tumors based on the clinical and roentgenographic findings alone is more likely to lead to error than when microscopic examination by an experienced pathologist is made. The author

TABLE II

Distribution of Tumors

Situation of Tumor	Males	Females	Total	Per Cent.
Femur	9	12	21	34.4
Tibia	4	8	12	19.8
Humerus	4	1	5	8.2
Ulna	2	3	5	8.2
Ilium	3	1	4	6.6
Radius	1	2	3	4.9
Fibula	2	0	2	3.3
Lumbar vertebra	1	1	2	3.3
Pubic bone	0	2	2	3.3
Scapula	0	1	1	1.6
Foot	0	1	1	1.6
Cervical vertebra	0	1	1	1.6
Sacrum	0	1	1	1.6
Eighth rib	0	1	1	1.6
Total	26	35	61	100.0

does not believe in routine irradiation of all bone tumors, nor does he consider it advisable as a primary or sole method of treating the giant-cell group of tumors. He feels that irradiation treatment takes too long and causes loss of valuable time in which metastasis may occur, and that the patient may lose the opportunity of cure by more radical measures. Too often benign and malignant tumors are treated without differentiation. Both soft and osseous tissues may be damaged, radiodermatitis and ulceration may occur, and, should operation be indicated, the tissue may break down, resulting in interference with conservative surgery.

However, at times irradiation is the only treatment possible, and the writer has seen large inoperable tumors of the pelvis slowly regress and ultimately be apparently cured under its influence; it is with this type and with vertebral tumors and following operations that irradiation is usually employed. In the ten years preceding 1926, irradiation was employed at the Clinic in eight cases,—in three, following biopsy; in four, in combination with curettage; and in one, following amputation. In the ten-year period following 1926, irradiation was used at the Clinic in twenty-two

TABLE III

Clinical Findings on Admission

	Males	Females	Total	Per Cent.
History of trauma	11	15	26	42.6
Limitation of motion	13	21	34	55.7
No previous treatment or operation	17	14	31	50.8
Previous treatment or operation	9	21	30	49.2

TABLE IV

Duration of Disease

DURATION OF SYMPTOMS PRIOR TO OPERATION AT THE CLINIC

Duration (Years)	Patients	Per Cent.
0 to 1	28	46.0
1 to 2	17	27.9
2 to 3	5	8.2
3 to 4	4	6.6
4 to 5	1	1.6
6 to 7	3	4.9
8 to 9	1	1.6
10	1	1.6
Not stated	1	1.6
Total	61	100.0

Average: 1.6 years

POSTOPERATIVE LENGTH OF LIFE

(All living except one *)

Duration (Years)	Patients	Per Cent.
0 to 2	5	8.2
3 to 4	7	11.5
5 to 9	25	41.0
10 to 14	15	24.6
15 to 19	9	14.7
Total	61	100.0

Average: 7.9 years

TOTAL DURATION OF DISEASE

Duration (Years)	Patients	Per Cent.
0 to 3	3	4.9
3 to 4	4	6.6
5 to 9	26	42.6
10 to 14	16	26.2
15 to 19	8	13.1
20 to 22	4	6.6
Total	61	100.0

Average: 10.3 years

* Died of embolism following prostatic operation elsewhere.

TABLE V

SUMMARY OF TREATMENT AND POSTOPERATIVE DURATION OF LIFE

Treatment at the Clinic	Patients	Per Cent.	Postoperative Duration of Life (Years)				
			0 to 2	3 to 4	5 to 9	10 to 14	15 to 19
Biopsy and irradiation..	7	11.5	2	1	2	1	1
Curettage alone........	11	18.0	0	2	3	5	1
Curettage and irradiation	13	21.3	1	1	7	4	0
Curettage and bone graft	10	16.4	1	1	7	0	1
Curettage, bone graft, and irradiation	4	6.6	1	0	1	1	1
Resection (in 2 cases plus irradiation).........	3	4.9	0	1	0	2	0
Amputation...........	13	21.3	0	1	5	2	5
Total	61*	100.0	5	7	25	15	9
Per Cent.............			8.2	11.5	41.0	24.6	14.7

* All living except one who died 10 years later of embolism following prostatic operation.

cases,—in four, after biopsy; and in eighteen, in combination with curettage, resection, bone graft, or amputation.

In an attempt to arrive at some conclusions of value, the case histories, clinical findings, laboratory findings, roentgenograms, and microscopic findings have been studied in sixty-one cases of giant-cell tumor in which patients have been operated on at the Clinic in the twenty-year period from 1916 to 1936. Cases of epulis of the jaw were excluded from consideration.

Twenty-six of the patients were males and thirty-five were females; the average age of each being twenty-seven and nine-tenths years (Table I). The situations of the tumors in these sixty-one cases are given in Table II and data relative to a history of the trauma, limitation of motion, and prior treatment are shown in Table III.

The duration of symptoms prior to operation at the Clinic, the postoperative length of life, and the total duration of the disease are given in Table IV.

BIOPSY AND IRRADIATION

Of these sixty-one patients, seven were treated by irradiation following biopsy on their admission to the Clinic (Tables V and VI). Three of these seven had had no previous treatment and were living eleven and a half years, three years, and eight months respectively, or an average of five and eight-hundredths years, following irradiation at the Clinic (Table VII). One of these three patients underwent amputation elsewhere three months after having taken a course of irradiation at the Clinic and after having been advised that there would be a temporary reaction with an increase in

size of the tumor. The other two of these three patients were apparently well at the time when this report was written and have had no further treatment. Four of the seven patients had received irradiation or treatment by manipulation or casts before coming to the Clinic, and they were living fifteen, seven and a half, five, and two and a half years respectively, following irradiation at the Clinic. Of these four patients, two are well; one has had repeated irradiations; and the other has had a bone-graft operation and treatment by irradiation. The average period of survival for these four patients following irradiation is six and forty-six hundredths years.

Biopsy was performed in 11.5 per cent. of the cases. It is a useful procedure in certain cases of tumor in which the diagnosis is difficult to

TABLE VI

SUMMARY OF TREATMENT AT CLINIC ACCORDING TO YEAR GIVEN

Year	Patients	Per Cent.	Biopsy and Irradiation	Curettage Alone	Curettage and Irradiation	Curettage and Bone Graft	Curettage, Bone Graft, Irradiation	Resection	Amputation
1916	3	4.9		1			1 R		1
1917	1	1.6							1
1918	2	3.3		1					1
1919	3	4.9							3
1920	5	8.2	2 R* R and X†			1			2 (1X)
1921	4	6.6	1 X	1	2 R R and X				
1922	3	4.9		2				1	
1923	0								
1924	1	1.6						1 R and X	
1925	2	3.3		2					
1926	6	9.8		1	3 X		1 X		1 X
1927	4	6.6			2 R and X	2			
1928	3	4.9	1 X			1	1 X		
1929	5	8.2			4 X	1			
1930	6	9.8		1		3			2
1931	6	9.8	1 X	2		1		1 X	1 X
1932	3	4.9	1 X		1 X				1 X
1933	1	1.6	1 X						
1934	2	3.3			1 X		1 X		
1935	1	1.6				1			
Total	61		7	11	13	10	4	3	13
Per Cent.			11.5	18.0	21.3	16.4	6.6	4.9	21.3

* R = radium.

† X = roentgen rays.

make from the clinical and roentgenographic findings. In the hands of an experienced surgeon little harm results, and, if the location of the growth is such that it makes it inadvisable to explore and to obtain a section of tissue of any size, then an aspiration needle is inserted and bits of tissue can be obtained for microscopic examination. Since serious hemorrhage may be encountered or infection may follow, which in some instances may result in disaster, the surgeon must be prepared to approach biopsy with the same degree of preparedness as if he were to do an extensive operation.

CURETTAGE

Eleven patients were treated by curettage alone or by curettage and cautery (Tables V and VI). Six of these patients had had no previous treatment and all were living and well seventeen, fourteen, thirteen and one-half (two patients), eleven, and six years later, or an average of twelve and five-tenths years, following curettage at the Clinic (Table VII). One of the six had a second curettage. The remaining five patients in the group had had some form of treatment before admission. One had been treated by means of curettage, cautery, and casts and had received considerable irradiation; this patient had a very offensive odor and was found to be suffering from a large cavity in the lower portion of the femur and from radiodermatitis, ulceration, osteomyelitis, and ankylosis of the knee joint. Treatment by curettage and the application of Dakin's solution proved of benefit, but four and a half years later the cavity, open wound, and damaged skin persisted. Another of the five patients had had curettage and radium treatment, but a sinus formed and, eleven years after treatment at the Clinic, he sustained a fracture, for which he was treated elsewhere. The third patient had previously been treated by manipulation and irradiation and was well nine years after curettage at the Clinic; the fourth had had treatment by irradiation previously and was well seven and a half years after curettage at the Clinic; and the remaining one had had curettage and treatment by a cast previously and was well four and a half years following curettage at the Clinic. These five have lived an average of seven and thirty-two hundredths years since curettage at the Clinic.

Thus, of the eleven patients in this group who were treated at the Clinic by curettage alone or by curettage and cautery, all are living at an average of nine and nine-tenths years following such treatment, and the results appear favorable in 81.8 per cent. of the cases. Two patients were admitted in such a condition as to make favorable prognosis practically impossible.

Bloodgood reported 80 per cent. cures by curettage and cautery. Simmons reported 62 per cent. cures from a review of the material in the Registry of Bone Sarcoma. In order to be successful, curettage must be employed for tumors which permit of complete removal, and a dry field is imperative; the mere stirring up of the tumor by the curette is both useless and dangerous, and causes the operation to fall into disrepute. Cautery

by thermal or chemical means aids in destruction of the tumor. The operation should be done under the tourniquet, and all loose particles should be washed from the wound. Packing may be necessary, but whenever possible the author prefers immediate closure of the wound layer by layer and the application of bandages and splints to obtain complete rest of the parts involved.

CURETTAGE AND IRRADIATION

Thirteen patients (21.3 per cent.) were treated by curettage and irradiation (Tables V and VI). Eight patients had had no previous treatment (Table VII), and of these two were living ten years, two * eight years, one seven years, and three six years following curettage and irradiation at the Clinic, or an average of seven and nine-tenths years. One died of embolism elsewhere, following a prostatic operation ten years after his dismissal from the Clinic. Five patients had had treatment before coming to the Clinic. One had previously had a tumor "removed" and was living ten years after treatment at the Clinic; this patient later sustained a fracture and joint damage that made walking and labor difficult. One had had a cast applied previously and was well ten years following treatment by curettage and irradiation at the Clinic. One had previously been treated by irradiation, with both roentgen rays and radium, and was living six and a half years after treatment at the Clinic, although two curettages and two courses of irradiation were necessary to obtain a cure. One had had treatment for fracture before coming to the Clinic and is still under treatment elsewhere, having had several curettages and bone grafts; non-union is still present, however, three and a half years following these procedures. One (Case 6) had previously been treated by "incision" and was cured by curettage and irradiation in fourteen months.

Thus, of the thirteen patients in this group who were treated by curettage and irradiation at the Clinic, eleven may be said to have remained well, making 84.6 per cent. "cures". One died ten years later of a cause not associated with tumor, and two have huge tumors of the lower portion of the femur and persisting disability which may bring them to amputation. Simmons reported 72 per cent. cures from curettage and irradiation in the Registry of Bone Sarcoma.

CURETTAGE AND BONE GRAFT

Ten patients, or 16.4 per cent., were treated by curettage and bone graft (Tables V and VI). Four of this group had had no previous treatment and were living and well fifteen and a half, eight and three-fourths, four and a half, and three-fourths years, or an average of seven and three-tenths years, following curettage and bone graft at the Clinic (Table VII). Six had had treatment before admission. Two of these had previously been treated by irradiation, — one (Case 3) is cured six and three-fourths years and one has slight disability but no recurrence seven and one-fourth

* The case of one of these patients (Case 9) is reported later.

TABLE VII

POSTOPERATIVE LENGTH OF LIFE ACCORDING TO TYPE OF TREATMENT AT CLINIC *

Type	Primary Treatment at Clinic	Primary Treatment Elsewhere	Total Patients	Postoperative Length of Life (Years)																		
				0 to 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19
Biopsy and irradiation . .	3	4	7	1†		1	1		1		1				1				1			
Curettage alone	6	5	11					2		1	1		1		2		2	1			1	
Curettage and irradiation.	8	5	13		1		1			4	1	2		4								
Curettage and bone graft . . .	4	6	10	1‡				1	2	2	1	2							1			
Curettage, bone graft, and irradiation . . .	1	3	4		1						1			1								1
Resection	1	2	3				1								1		1					
Amputation . .	8	5	13				1		3	1			1	1			1			2	2	1
Total	31	30	61	2	2	1	4	3	6	8	5	4	2	6	4		4	1	2	2	3	2
				5			7		25					15					9			
Per cent. . . .	51	49	100	8.2			11.5		41.0					24.6					14.7			

* All patients living except one who died ten years postoperatively of an embolism following a prostatic operation.

† Eight months.

‡ Nine months.

years following curettage and bone graft at the Clinic. One (Case 5) had previously undergone "excision and bone graft" and is well five and three-fourths years; one had been treated by aspiration and is well five years; and two had had some form of splint treatment and are living and well eight and three-fourths years (Case 2) and six years (Case 7) following curettage and bone graft at the Clinic, or an average of seven and nine-tenths years.

Thus, although three patients did have in addition some irradiation, the results for this group of patients treated by curettage and bone graft were 100 per cent. good. The operation entails considerable judgment in the selection of cases and requires the strictest asepsis and orthopaedic skill.

CURETTAGE, BONE GRAFT, AND IRRADIATION

Four patients (6.6 per cent.) were treated at the Clinic by curettage, bone chips, or grafts and irradiation (Tables V and VI) and these are living on an average of nine and twelve-hundredths years later (Table VII). One of these patients had previously been subjected to biopsy and had had

two courses of irradiation. This patient had lost forty-four pounds (twenty kilograms) and was considered to have a malignant tumor, yet is living seventeen months after operation with apparently no evidence of recurrence and is in excellent health. A second patient (Case 4) had been treated for tuberculosis and had secondary anaemia, but is living more than seven years after operation; there is no evidence of recurrence, although the patient limps and has soreness about the hip. The third patient had had six irradiation treatments and curettage prior to admission to the Clinic and received at the Clinic treatment by roentgen rays, radium, curettage, and bone insert over a period of two years. This patient has a residual deformity, but no recurrence nineteen years following treatment at the Clinic. The fourth patient in the group had had no previous treatment and is well and has good function ten years following operation at the Clinic.

The insertion of bone chips into large cavities following curettage aids in filling the defect and stimulates the formation of bone, external fixation often being necessary following operation in cases in which tumors are large. The implanting of radium into cavities is seldom practised because of the increased risk of infection. Excessive irradiation preoperatively or postoperatively prevents repair of bone and, when accom-

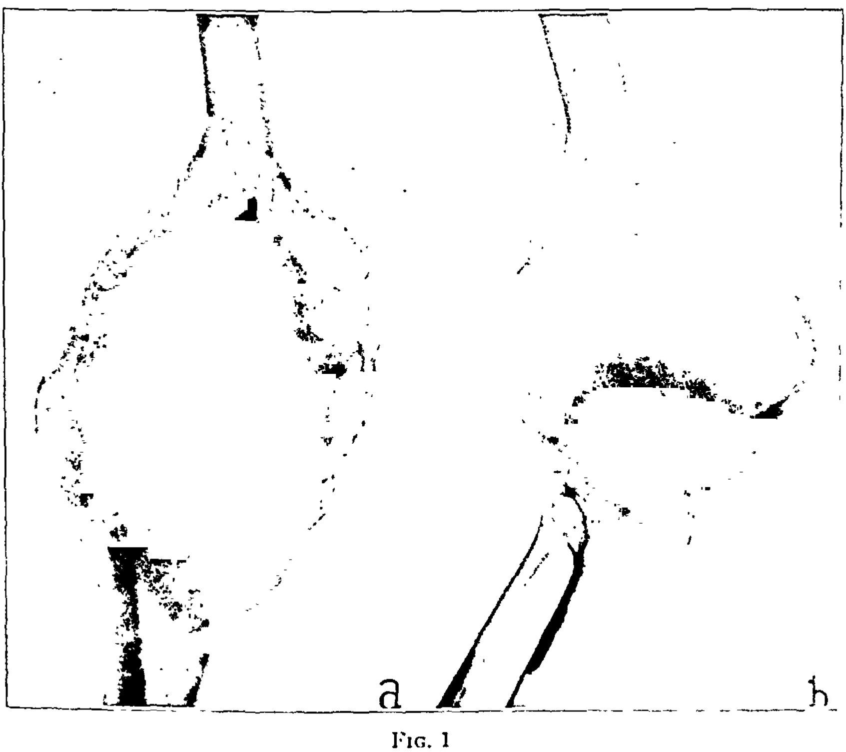

FIG. 1

Anteroposterior and lateral views, showing huge giant-cell tumor of the lower end of the left femur.

FIG. 2

Giant-cell tumor of the distal end of the radius.
a: Before operation.
b: Nine months after curettage and autogenous bone graft.

panied by the added trauma of surgery, may lead to ulceration and to loss of the grafts.

RESECTION

Three patients (4.9 per cent.) were treated by excision, and are living on an average of nine years later (Tables V, VI, and VII). One had had no previous treatment and is living three years later; one had had neurectomy for pain and is well thirteen and a half years later; and one had undergone an exploratory operation, a diagnosis of sarcoma having been made, and is well eleven and three-fourths years following resection at the Clinic.

FIG. 3

Giant-cell tumor of the distal end of the left radius.
a: Before operation.
b: Six years after removal by curettage and autogenous bone graft.

The author agrees with Simmons that this is the operation of choice when feasible; its application, however, is limited usually to such bones as the radius, the ulna, the ribs, the head of the femur, and the fibula. Simmons reported 100 per cent. good results from the Registry of Bone Sarcoma.

AMPUTATION

Thirteen patients (21.3 per cent.) were treated by amputation and all are living on an average of nine and sixty-eight hundredths years later (Tables V, VI, and VII). Eight had had no previous treatment at the Clinic. One had had curettage and cautery at the Clinic two years prior to amputation and is living and well nineteen years later. One had curettage and cautery nine months prior to amputation and is living sixteen years later. One patient (Case 8) had been advised to undergo amputation but instead had had treatment consisting of curettage and cautery, finally coming to amputation six years later; this patient is living and well eleven years following amputation. One had received treatment by curettage, cautery, and irradiation three and a half years prior to amputation, a sinus persisting. The pathologist reported osteogenic sarcoma but, on review, corroborated the original diagnosis of benign giant-cell tumor; however, this diagnosis has not as yet been accepted as final and the tissue is being submitted to further study. This patient is living two and a half months following amputation. Two patients are living sixteen and eleven years, respectively, following amputation, and two, who had postoperative irradiation, are living six (Case 1) and five years, respectively, following amputation, or on an average for the eight patients of ten and seven-tenths years.

Five patients had had treatment before consultation. Three had had manipulations for injuries and were living thirteen and a half, nine and a half, and five and a half years following amputation at the Clinic. One had undergone exploratory operation and was living five and a fourth years later, and one was treated for syphilis and was living seventeen and three-fourths years following amputation. The average postoperative length of life for the five patients in the group, therefore, was eight years.

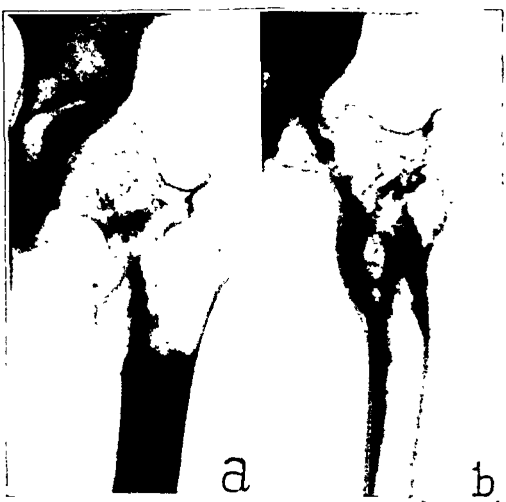

FIG. 4

Giant-cell tumor of the upper end of the left femur.
a: Before operation.
b: Two years after curettage and crushing in of the cortex.

Amputation may be the only recourse in some cases of

extensive involvement, especially of the knee joint, or following excessive irradiation with the development of ulceration and infection. For older patients, when the function of the lower extremity is seriously impaired and life would be endangered by attempts to save the extremity, amputation is preferable. At the Clinic amputation has been used less with added experience and earlier diagnosis, eight amputations having been performed in the five-year period from 1916 to 1921, but only five having been performed during the fifteen-year period from 1921 to 1936. Our studies indicate that at least in some instances amputation could have been avoided had early and conservative measures been employed. No doubt, in the future the more common use of roentgenographic examination for painful lesions of bone will bring patients to the orthopaedic surgeon at a time more favorable for treatment.

ILLUSTRATIVE CASES

CASE 1. A girl student, twenty-two years of age, came to the Clinic on June 23, 1930, because of swelling, pain, and a tumor above the left knee. She recalled having injured this knee several times about three years previously, and approximately six months later pain in the knee had developed. An orthopaedic surgeon had thought that the condition was malignant and had advised amputation.

Examination at the Clinic disclosed a huge mass, palpable in the lower end of the femur, and a clinical and roentgenographic diagnosis of giant-cell tumor was made (Fig. 1). The blood count was normal; the urinalysis was negative; and the Wassermann test was negative. Roentgenograms of the thorax were also negative.

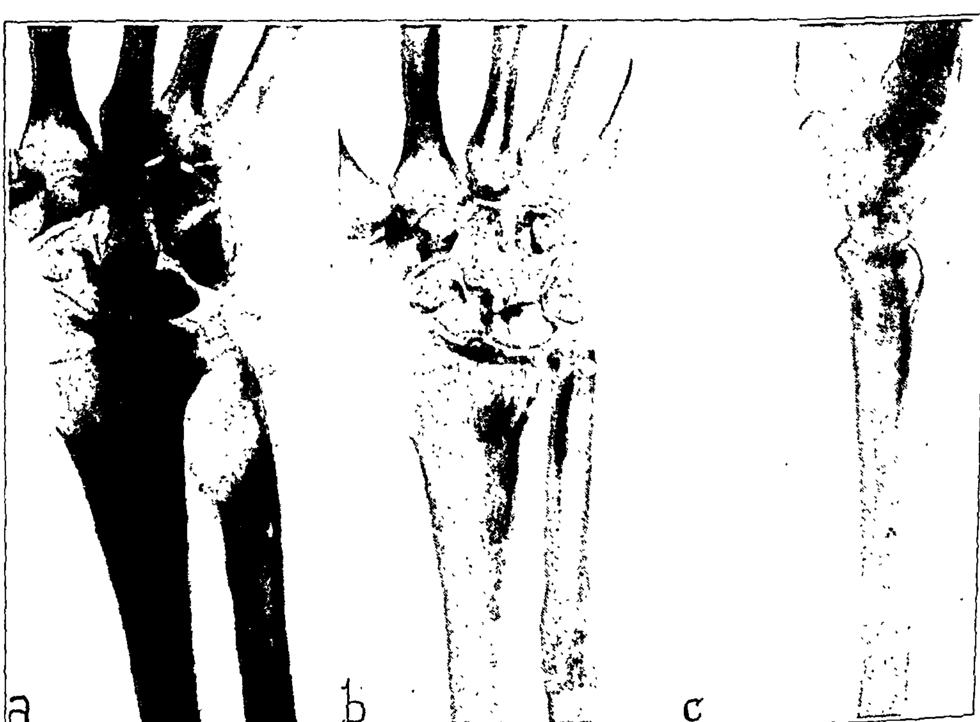

FIG. 5

Recurrent benign giant-cell tumor of the right ulna.
a: Anteroposterior view, before operation.
b and *c:* Anteroposterior and lateral views, nine months after resection of the tumor and application of an autogenous bone graft taken from the fibula.

Because of the extensiveness of the tumor it was thought inadvisable to carry out conservative measures and, on June 26, 1930, amputation was performed. No other treatment was given and the patient was dismissed from the hospital on the thirteenth postoperative day.

In a letter received in March 1931, she stated that she had gained about fifty pounds (twenty-two and seven-tenths kilograms) and was in excellent condition. In January 1936, she again reported that she was well and that further treatment had not been necessary.

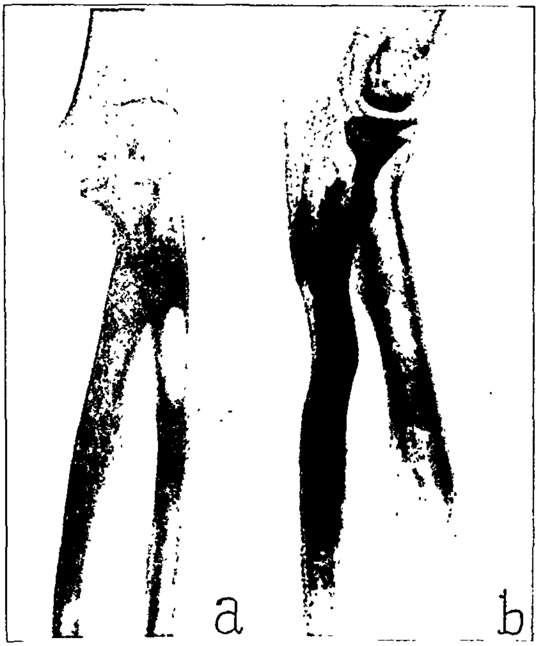

Fig. 6

Giant-cell tumor of the proximal portion of the left ulna.
a: Before operation.
b: Nine months following excision and cautery.

Case 2. A youth, aged eighteen years, came to the Clinic on May 28, 1927, because of a growth in the lower portion of the left radius of three months' duration. Two weeks prior to the onset of swelling he had sustained several injuries in the region of the right wrist. Roentgenograms had been taken and a splint had been applied for giant-cell tumor.

On examination at the Clinic the patient appeared to be in good condition and had not lost weight. Urinalysis was negative and the blood count was within normal limits. A roentgenographic diagnosis of giant-cell tumor was made (Fig. 2, *a*).

At operation on May 31, 1927, the tumor was removed and a bone graft, which had been taken from the right tibia, was inserted. This

Fig. 7-A

Fig. 7-B

Giant-cell tumor of the left humerus with a pathological fracture.
Fig. 7-A: Before operation.
Fig. 7-B: Nine months after curettage and application of an autogenous bone graft.

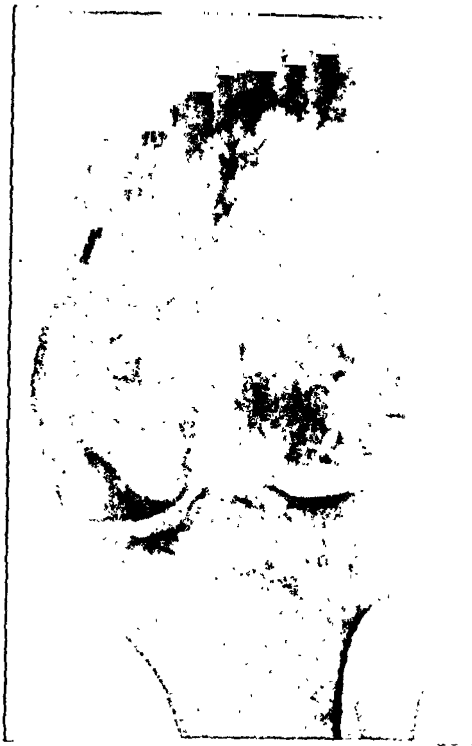

FIG. 8

Giant-cell tumor of the lower end of the right femur with involvement of the knee joint.

was forced into the medullary cavity and against the remaining epiphysis, after which multiple bone chips were packed about the area to aid in the formation of bone. The pathologist reported "foreign-body giant-cell tumor". No subsequent treatment was given. Convalescence was uneventful and the patient left the hospital at the end of the fifth week.

In a letter received in January 1936, the patient said that he was well and that he had had no further treatment nor any recurrence of the tumor; he also said that his arm was "just as strong as it was before the injury".

CASE 3. A housewife, aged thirty-eight years, came for examination on April 8, 1929, complaining of pain, limitation of motion, and partial disability of the left wrist of nine months' duration. She had injured this wrist five months previously and, over a period of about five weeks prior to her admission, she had noticed the formation of a tumor. She had been given two roentgen treatments prior to admission.

Examination at the Clinic revealed swelling, tenderness, and limitation of motion of the left wrist. There had been no loss of weight. The Wassermann test was negative; the blood count was normal; and urinalysis was negative. A clinical and roentgenographic diagnosis of giant-cell tumor of the lower left radius was made (Fig. 3, *a*).

At operation on April 11, 1929, under tourniquet, the entire tumor was removed with a curette, and an autogenous bone graft was inserted. Subsequent treatment by roentgen rays, radium, or toxins was not given. The patient was dismissed from the hospital twenty-four days following admission. At that time she was wearing a plaster cast.

In a letter received in January 1936, about seven years later, she said that she had had no further treatment and no further recurrence, and that she was "greatly pleased" with the result of the operation and had "good function".

CASE 4. A girl student, aged eighteen years, came to the Clinic on February 27, 1928, because of pain in the upper portion of the left femur. She stated that this pain had been present for the previous six months and had caused her to limp. There was no history of injury. A diagnosis of tuberculosis had been made and a plaster cast had been applied; she had worn the cast for a couple of months.

On examination at the Clinic the Wassermann test and urinalysis were found to be negative. The tonsils had been removed previously; roentgenograms of the thorax were negative. Roentgenograms of the left femur were diagnosed by the roentgenologist as showing giant-cell tumor of the upper part of the left femur (Fig. 4, *a*). The patient had secondary anaemia and had lost about fourteen pounds (six and four-tenths kilograms).

On March 1, 1928, the patient was operated on. The tumor was thoroughly removed with a curette and the cortex was crushed in. The wound was closed without drainage and a spica cast was applied. The pathologist reported giant-cell tumor. No subsequent treatment was given and the patient was dismissed with a walking caliper splint.

The patient was seen about twenty months later, in January 1930, and, because of possible recurrence of the tumor, she was operated on again on January 23.

The tissue removed was reported negative by the pathologist, there being no evidence of tumor. Two courses of irradiation, each over three areas, were given,—the first on February 10, 1930, and the second on March 17, 1930. The following technique was used: The roentgen rays were generated at 135 peak kilovolts, filtered through six millimeters of aluminum at a distance of sixteen inches (forty and six-tenths centimeters), with five milliamperes of current, and were applied for twenty-five minutes the first time and twenty-two minutes the second time. The patient was living and well eight years after the original operation.

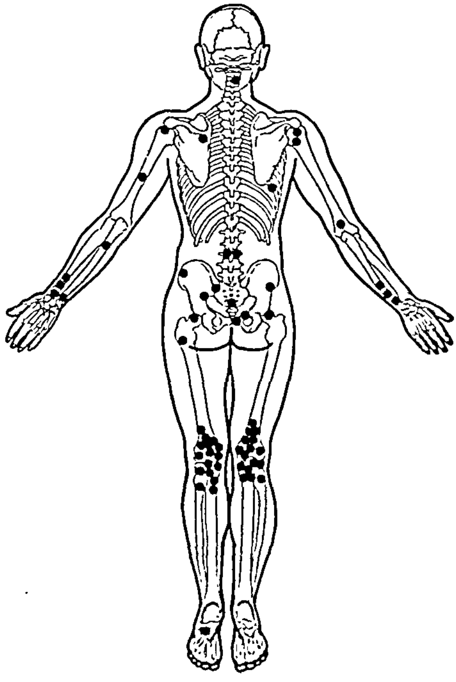

Fig. 9

Showing various situations of giant-cell tumors.

Case 5. A shoemaker, thirty years of age, came to the Clinic on May 5, 1930, *complaining of pain in the lower* right forearm and of the formation of a tumor. This condition had been present for about two and a half years. He had been treated by his local physician for rheumatism. Six months after the onset of the condition he had consulted a surgeon, and a tumor of the right ulna had been excised and a bone graft had been inserted. There had been recurrence of pain and swelling.

Roentgenographic examination at the Clinic revealed giant-cell tumor of the lower end of the right ulna (Fig. 5, *a*). Roentgenograms of the thorax were negative.

The patient was operated on May 9, 1930. The entire lower third of the right ulna was excised and about four and one-half inches (eleven and four-tenths centimeters) of the left fibula was resected, inserted in the area, and held with beef-bone screws. A cast was then applied. The pathologist reported foreign-body giant-cell tumor. No subsequent roentgen therapy nor toxin treatment was given.

The patient was well and had obtained a good functional result when last heard from, nearly six years following operation.

Case 6. A stenographer, aged twenty-eight years, reported for examination on December 5, 1934, because of pain in the left forearm of about a year's duration. Her general health had been good. Two incisions had been made in the forearm, but a definite diagnosis had not been given.

On examination at the Clinic urinalysis was negative and the blood count was normal; roentgenograms of the thorax were also negative. The clinician and roentgenologist considered the possibility of metastatic malignancy of the upper ulna (Fig. 6, *a*).

An operation was performed under tourniquet on December 7, 1934. The tumor was completely removed and the area was temporarily drained. The pathologist reported benign, foreign-body giant-cell tumor. The surgeon advised postoperative roentgen therapy. Two courses of irradiation, each over two areas, were given,—the first on December 13, 1934, and the second on January 19, 1935. The following technique was used: The roentgen rays were generated at 135 peak kilovolts, filtered through six millimeters of aluminum, at a distance of sixteen inches (forty and six-tenths kilograms), with five milliamperes of current, and were applied for twenty-five minutes.

In a letter received in March 1936, the patient said that she was well, and roentgenograms which were forwarded to us revealed complete disappearance of the tumor.

CASE 7. A boy, aged sixteen years, came to the Clinic on February 17, 1930, complaining of pain in the left arm of eighteen months' duration. He had also fractured this arm while wrestling six days previously.

Examination revealed tenderness, swelling, and abnormal mobility of the upper third of the left humerus. The patient was wearing a splint. The Wassermann test was negative; urinalysis was negative; and the blood count was within normal limits. There had been a slight loss of weight. A roentgenographic diagnosis of giant-cell tumor with pathological fracture was made (Fig. 7, *a*). Roentgenograms of the thorax were negative.

On February 20, 1930, the tumor was thoroughly excised with a curette and a bone graft from the left tibia was used as an intermedullary plug, multiple bone chips being packed around the fracture line. The pathologist reported giant-cell tumor. No subsequent treatment by irradiation, by radium, or by toxins was given.

The patient reported six years later, in January 1936, that he was in excellent health and had excellent function, and that there had been no recurrence of the tumor.

CASE 8. A farmer, aged twenty-three years, was admitted to the Clinic on May 30, 1919, because of pain in the lower part of the right femur of six years' duration. His general condition had been good and he gave no history of previous injury.

Examination revealed limitation of motion of the right knee joint and definite swelling in the lower end of the femur. The Wassermann reaction was negative; the temperature was 99.2 degrees, and the urinalysis and a roentgenogram of the thorax were negative. Secondary anaemia was present. The roentgenographic diagnosis was giant-cell sarcoma (Fig. 8). Because of the extensiveness of the mass and the involvement of the joint surface, amputation was advised, but the patient requested that an attempt be made to save the leg. On June 12, 1919, exploration was carried out under tourniquet and thorough curettage was done; the wound was closed without drainage. The pathologist reported benign, xanthic, foreign-body giant-cell tumor.

The patient continued to use the extremity and reported later that he felt that the tumor was increasing in size. His general health was good, however, and his weight continued normal. In 1925 he decided to undergo amputation, which had been advised at the time of his first consultation, and amputation was performed on April 24, 1925.

The patient reported in January 1936 that he was in good health and had had no recurrence of the tumor, almost sixteen years following the original operation.

CASE 9. A boy, aged fourteen years, was examined at the Clinic on August 20, 1927, because of limitation of motion and swelling of the left knee of one year's duration. A diagnosis of sarcoma had previously been made.

On examination at the Clinic the Wassermann test was negative; the leucocyte count was 12,900 per cubic millimeter; and roentgenograms of the thorax were negative. A preoperative roentgenographic diagnosis of osteochondroma, probably malignant sarcoma, of the left femur was made.

An operation was performed on August 26, 1927. Under tourniquet, the tumor was thoroughly removed with a curette and the knee was manipulated and straightened. Ten radium needles were inserted. The tumor had destroyed the bone posteriorly, so that the vessels were exposed and were covered only by a thin shell, which was loose. A plaster cast was applied. No subsequent treatment was given at the Clinic or elsewhere.

Almost nine years later, in March 1936, the patient reported that he had had no recurrence and was in good health.

SUMMARY AND CONCLUSIONS

The treatment of benign giant-cell tumors varies, but the physician in charge has at his disposal the means of establishing an accurate diagnosis,

POSTERIOR DISLOCATION OF THE HIP WITH FRACTURE OF THE ACETABULUM *

BY WILLIS C. CAMPBELL, M.D., MEMPHIS, TENNESSEE

Minor fractures about joints associated with dislocations are of frequent occurrence, but they are not often of clinical significance. However, dislocation of the hip with fracture of the rim or of the roof of the acetabulum presents a problem of importance to which little attention has been given, as demonstrated by the high percentage of poor results in those cases not efficiently treated. Of eighty cases of posterior dislocation of the hip from the author's private records, this complication was present in thirty, which shows that it is not of infrequent occurrence. Sixteen of these were fresh cases and fourteen were of many months' or years' duration. Of fifty cases of dislocation of the hip not associated with fracture of the acetabulum, twenty-seven were fresh and twenty-three were old.

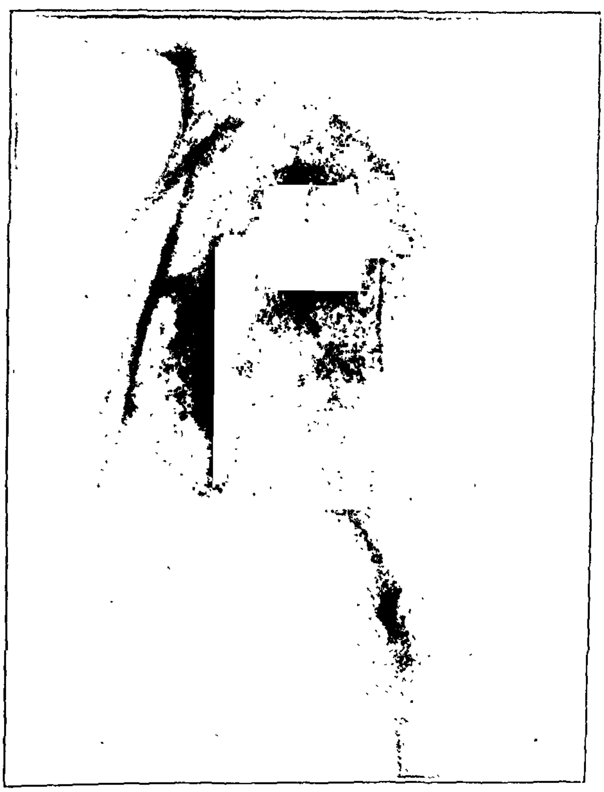

FIG. 1

Type-I dislocation, five years after reduction. Excellent function. Note condensation of the acetabulum.

The thirty cases of dislocation of the hip, accompanied by fracture of the acetabulum, may be divided into three different types, as demonstrated by the roentgenograms.

Type I: This is a fracture at the superior posterior aspect of the acetabulum of an irregular, more or less triangular piece of bone. The head of the femur is subluxated slightly upward and backward. The limb may be slightly adducted or in a normal position, and motion is definitely limited, especially in abduction, which is largely due to pain elicited on passive motion. There is slight, if any, difference in position of the trochanters as related to Nelaton's line. The roentgenogram clearly demonstrates a fracture of the acetabulum, but the slight upward and backward displacement of the head of the femur may not be recognized without close inspection and comparison with a roentgenogram of the normal hip. Stereoscopic roentgenograms

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 19, 1936.

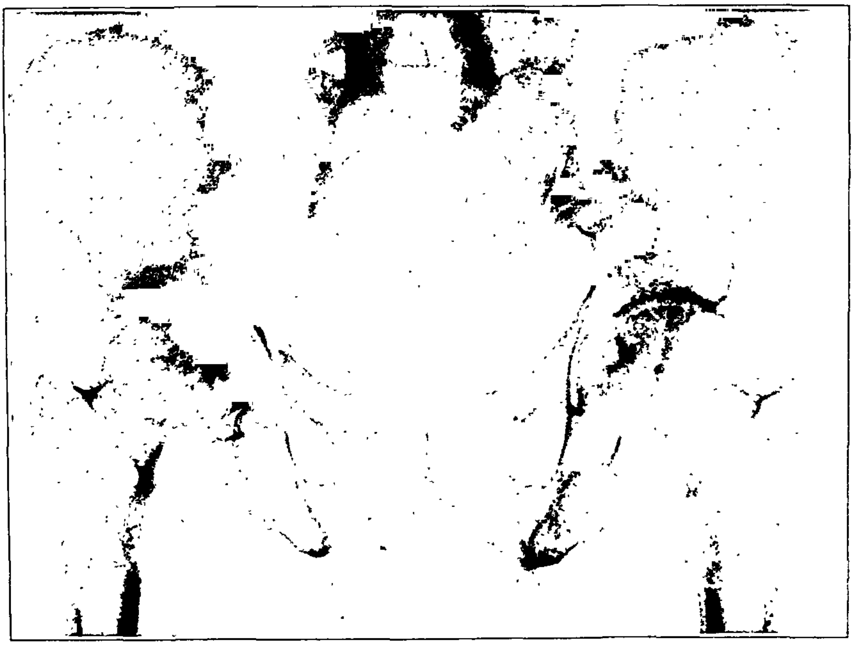

Fig. 2

A proved Type-I subluxation or dislocation. Note difficulty in distinguishing it from a normal hip.

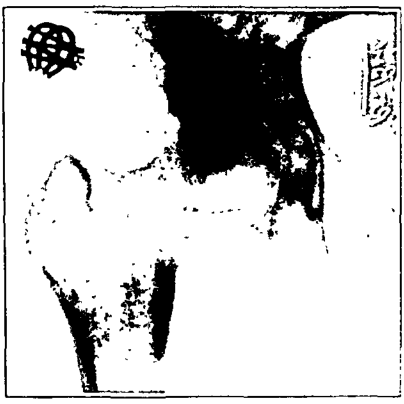

Fig. 3

Same case as shown in Fig. 2, after reduction. Reduction was accomplished with an audible snap.

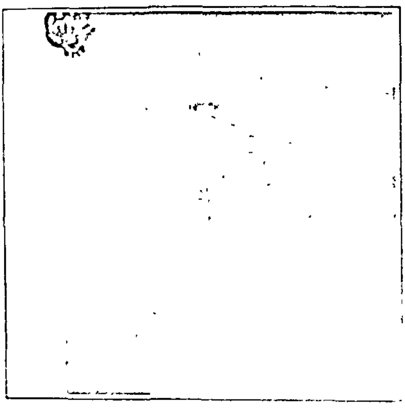

Fig. 4

Same case as shown in Fig. 3, three years later. Perfect function.

give more evidence as to the exact location of the head of the femur. Failure to recognize and diagnose the actual lesion is common, with the result that there is irreparable damage, when efficient treatment would bring about normal or almost normal relations in a very high percentage of cases. The distressing disability observed in Type I, if unrecognized, is the reason for calling attention to this subject.

Type II: The head of the femur is further displaced and is partially above the acetabulum, the lower half or two-thirds being apparently within the acetabulum, as demonstrated by the anterior posterior roentgenogram. The fragment from the acetabulum is displaced from half an inch to one inch above the acetabulum, much further than in Type I. The limb is adducted and rotated upward until the trochanter is high and abduction is nil.

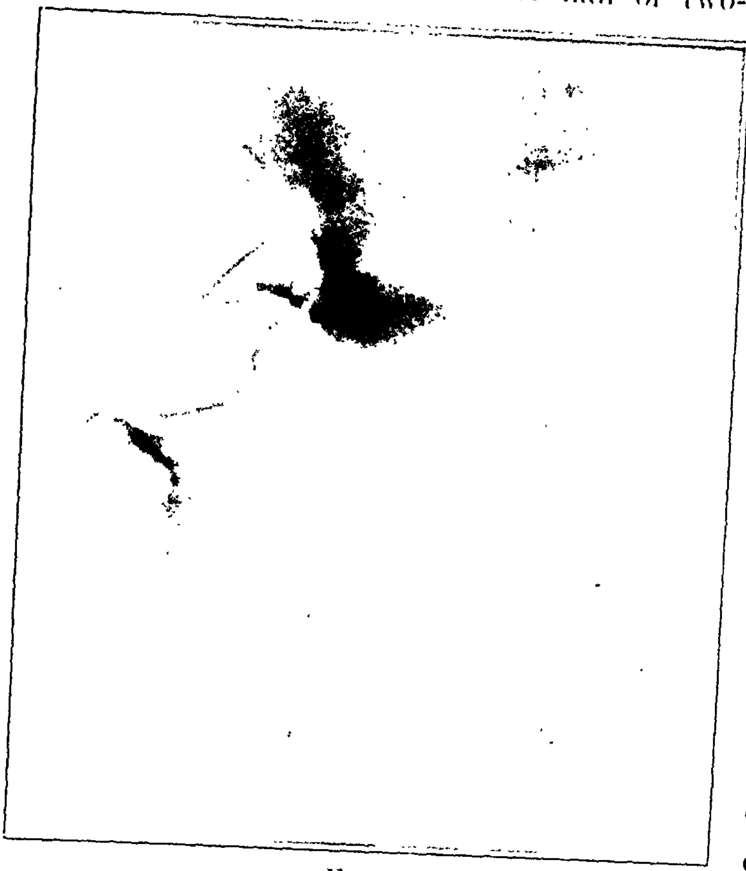

Fig. 5
Type-II dislocation, showing partial dislocation of the head from the acetabulum.

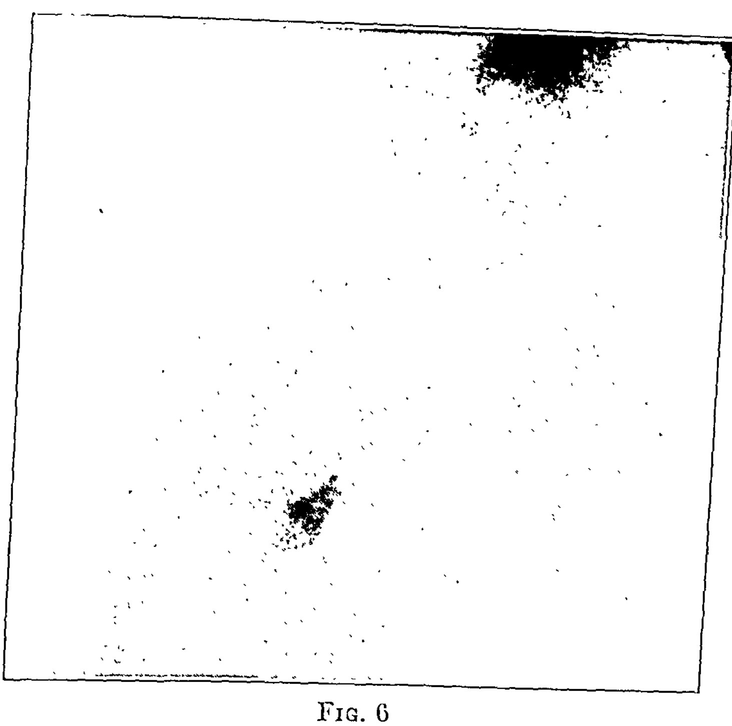

Fig. 6
Same case as shown in Fig. 5, after reduction.

Type III: There is a complete dislocation of the head of the femur and of the detached fragment. The position of adduction and internal rotation and elevation of the trochanter is typical of any dorsal dislocation of the hip joint. In Types II and III diagnosis is evident from the clinical signs, symptoms, and the roentgenograms, if the average intelligence is employed.

The mechanism of injury is usually force applied from below with the hip flexed, as in an automobile collision when the knee strikes against the instrument board. Also, force acting from above with

Fig. 7

Type-III dislocation. Complete dislocation of the head from the acetabulum with marked upward and backward displacement.

the hip flexed may cause the lesion. The mechanism is somewhat different from that which usually occurs in a traumatic posterior dislocation of the hip,—namely, forcible adduction and flexion of the hip. Some facts regarding the nature of the injury were secured in twenty-four of the thirty cases. Twenty-one patients were injured in automobile accidents; of these, six gave a definite history of forcibly striking the knee against the instrument board; six gave a history of violent collision; and in eight cases the exact mechanism could not be determined. In one case only was force received from above; this injury was caused by a falling tree which struck the posterior aspect of the hip when the patient was in a stooping position. Evidently this lesion was exceedingly rare before the day of the automobile, which probably accounts for the failure in diagnosis so frequently observed in Type I.

Fig. 8

Same case as shown in Fig. 7, after reduction

FIG. 9
Old unreduced Type-II dislocation.

The treatment for this dislocation-fracture in fresh cases is exactly the same as that employed for dorsal dislocation of the hip joint. Traction is applied in the line of deformity, which is flexion with adduction. Reduction is accomplished with a definite snap, after which movement can be made in all directions. The snap, of course, is more exaggerated as the degree of dislocation becomes greater, as in Types II and III. The fragment is evidently attached to the capsule which is approximately in the normal position after reduction has been accomplished. After reduction the hip is fixed in slight hyperextension and abduction with a cast extending from the toes on the affected side to the nipple line. This is bivalved at the end of three weeks and active and passive motion is instituted. Walking with the aid of crutches is permitted at the end of six weeks. Walking without support is begun at the end of ten or twelve weeks. Open operation was required in only three cases, one of which the author believes could have been accomplished by manual reduction.

Of the thirty patients, twenty-four were males and six were females. The age incidence was as follows:

18 years	1 case
20 to 30 years	8 cases
30 to 40 years	6 cases
40 to 50 years	5 cases
50 to 60 years	7 cases
60 to 70 years	2 cases
70 to 80 years	1 case
Total	30 cases

The average age was thirty years. There were no cases in children, although no age is exempt.

Of the sixteen fresh cases, six were Type I, six were Type II, and four were Type III. In the three cases in which open reduction was employed the end result is unknown in one case, and two cases are too recent to report on, although indications are that after three and six months, respectively, good function will be secured. Of the thirteen cases in which

manual reduction was secured, excellent results were obtained in six; the patients have active motion ranging from 75 to 100 per cent., and they have returned to their former occupations. Two cases are too recent to report on and four patients could not be located. In only one case was a poor result obtained.

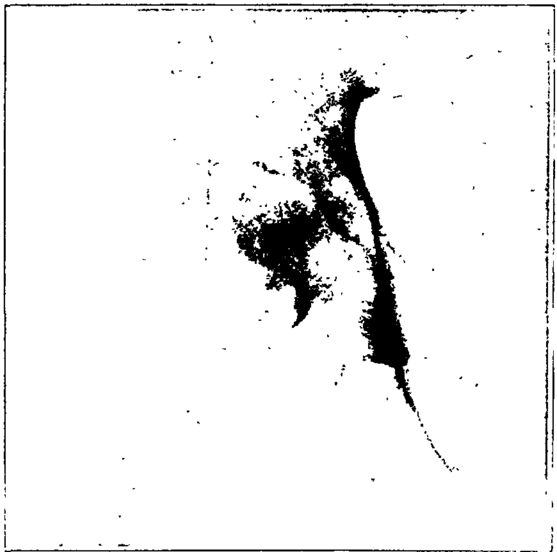

Fig. 10

Same case as shown in Fig. 9, after modified arthroplasty.

Therefore, the prognosis is excellent in a very high percentage of fresh cases, regardless of the type, if efficient treatment is instituted at once. In one case (Type 1) with an excellent functional result, there was definite condensation of the upper and posterior rim of the acetabulum after the lapse of five years. Presumably this occurs in all cases, but no patient has returned on account of local osteo-arthritis.

There were fourteen patients with old dislocations; eight of these submitted to open operation. Three types of operation were employed: (1) open reduction with reconstruction of the acetabulum; (2) a partial or modified arthroplasty when the head of the femur was still invested with cartilage; (3) a complete arthroplasty, which consisted of completely remodeling the head of the femur and the acetabulum. The end results in these eight cases were far from satisfactory. The best results were secured in two patients who had complete arthroplasties; in the remaining

Fig. 11

Same case as shown in Fig. 10, one year later, showing degenerative changes of the head of the femur. The hip was painful.

FIG. 12
Old unreduced Type-III dislocation.

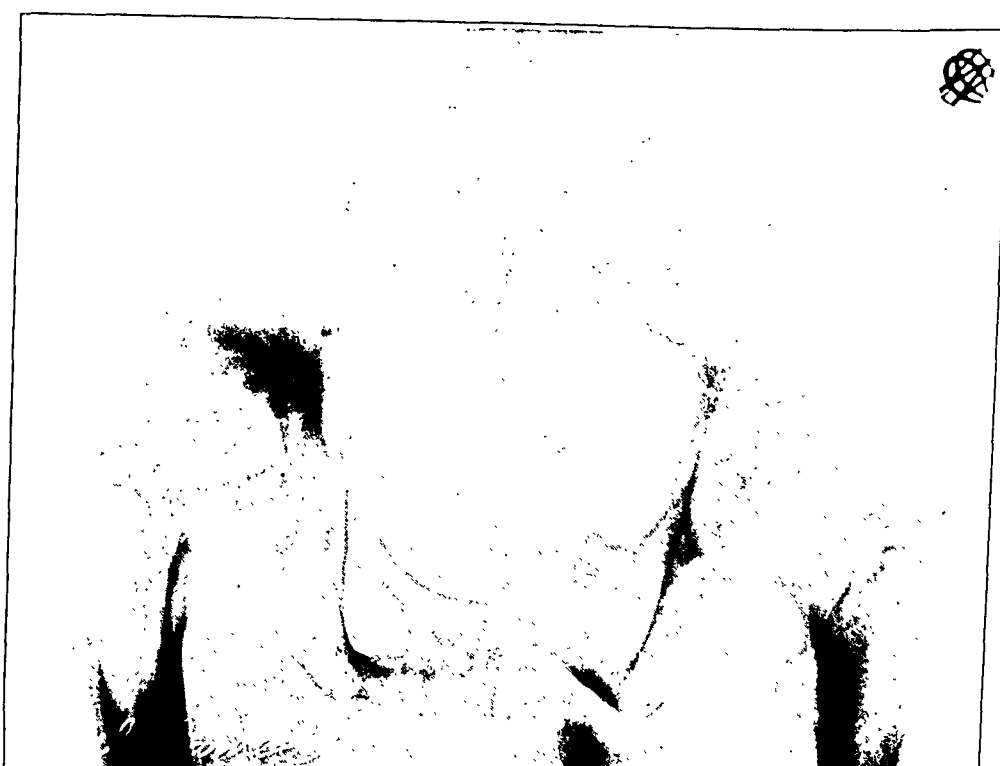

FIG. 13
Same case, after reconstruction of the acetabulum. The hip was painful.

Fig. 14
Old unreduced Type-I dislocation.

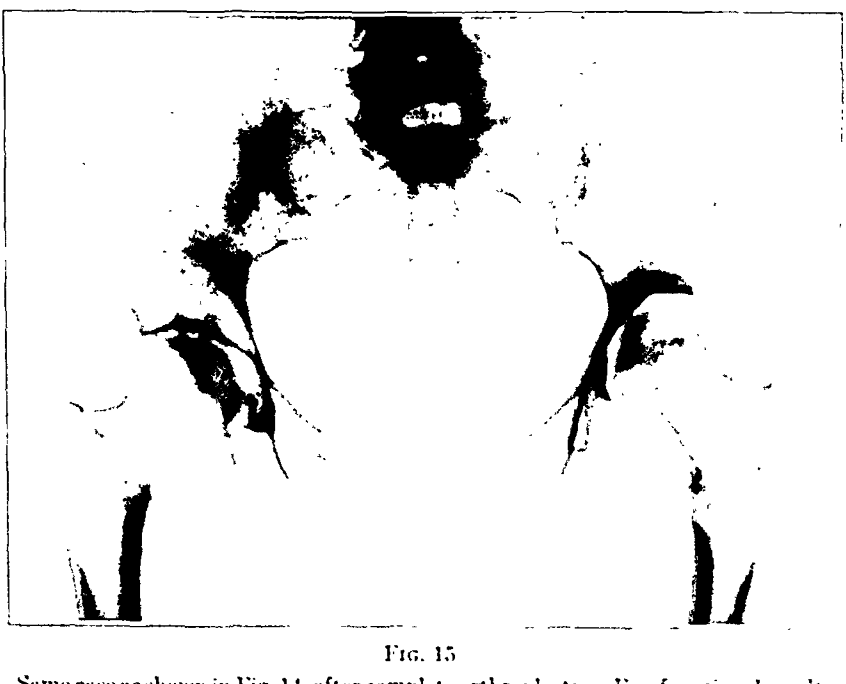

Fig. 15
Same case as shown in Fig. 14, after complete arthroplasty. Fair functional result.

six cases the results were poor, as slight, if any, improvement was obtained. As stated in former contributions, partial arthroplasties are unsatisfactory, since articular cartilage rapidly degenerates when removed from a joint cavity and leaves a poor foundation for a new joint. The circulatory changes result in disintegration and a painful hip.

Undoubtedly induction of osseous fusion of the hip joint would give the highest percentage of excellent results; in each case this measure was offered, but it was flatly declined when the patient was told that there was a possibility of function with the use of any other procedure.

CONCLUSIONS

1. The relatively frequent occurrence of fracture of the acetabulum associated with dislocation of the hip is demonstrated by the fact that it was present in 37.5 per cent. of this series of cases. Prior to the time of the automobile this lesion was rare.

2. Many dislocations, especially those of Type I, are not recognized until there has been irreparable damage, of which only partial restoration is ever possible. The fourteen old cases demonstrate the poor end results which may be expected from inefficient treatment.

3. With an early diagnosis and efficient treatment, excellent function should be secured in practically every case.

THE TREATMENT OF SURGICAL TUBERCULOSIS BY VASELIN INJECTIONS AND CLOSED PLASTER-OF-PARIS BANDAGES

BY VLADIMÍR JEŘÁBEK, M.D., PRAGUE, CZECHOSLOVAKIA

From the Clinic for Orthopaedic and Children's Surgery *

The treatment of surgical tuberculosis has undergone many changes in its development, extending over a considerable period of time. Along with the rapid progress made within the past century, the opinion that tuberculosis should be treated surgically was generally accepted. In an otherwise successful period of radicalism much harm resulted in the field of bone and joint tuberculosis. Foci of this disease were freely opened, the site of the disease eradicated, and the articular surfaces, even in the florid cases, resected; in brief, every effort seemed to be directed to a mechanical removal of diseased tissue and the causative organisms. As might have been expected, the results were unsatisfactory. Miliary metastasis was frequent, often causing death. Cold abscesses, which were widely incised, in spite of the strictest asepsis in the after-dressings, became secondarily infected with pus-producing organisms, thus perpetuating a purulent discharge which drained the patient's vitality until, in many cases, death ensued from amyloid degeneration.

These fatalities led those who opposed this course, either from conviction or from personal distaste for operation, to seek new methods of treatment. Calot declared: "If you open tuberculosis you thereby open the door for death." The conservative method won the battle and became an unwritten law in spite of the contrary opinion of prominent authorities. A new method of treatment was adopted,—namely, complete rest, either in plaster-of-Paris bandages or by extension. Much effort was spent in the search for new methods of vaccination and, although these efforts often led to good results, the desired goal was not attained. It would seem, therefore, that a more active course of treatment should be sought which would hasten recovery and yet not endanger the life of the patient.

In this paper the author wishes to consider those types of surgical tuberculosis which present grave obstacles to actual surgical interference. To this group belong para-articular foci of tuberculosis.

As the writer has already stated in an article devoted to these interesting types of bone tuberculosis, operation is indicated in such cases only when the roentgenogram shows distinct signs of a circumscribed cavity. We know from experience that the clearing out of such a focus is not dangerous, but before the cavity limits itself a sequestrum forms within. The sequestrum appears so often that Sorrel, in his *monograph*, lists it as an obvious sign of the focus of tuberculosis.

Sequestra, especially the larger ones, have a tendency to spontaneous-

* Prof. Jan Zahradníček, M.D., Director.

evacuation: only the smaller sequestra may be absorbed. That is why fistulae are often found near such a focus. A fistula often announces a disease of the bone when up to that time there have been only slight, if any, symptoms. A little carelessness on the part of the patient, or of those about him, may be sufficient to disclose foci of disease which have been draining for weeks. Unfortunately, this happens quite often, so that we frequently see fistulae which have been pyogenically infected. Similarly, cases of caries calcanei and spina ventosa of short and long bones are met with in which incisions, made too late by the surgeon, have led to secondary infection.

In treating these and other complications, followers of conservative trends were satisfied by the application of a plaster-of-Paris bandage with an aperture for the fistula, through which the dressings were changed. Thus, treatment resolves itself into a question of clean dressings; these, however, are purely aesthetic and do not prevent superinfection. The author considers it necessary to eradicate the foci even if secondary infection has taken place or if the abscess has not yet broken through. Conservative treatment is too prolonged and too passive, does not prevent the possibility of eventual extension into the joint, and is, therefore, unsatisfactory.

The writer's procedure is as follows: The patient is prepared in the customary manner and a wide operating surface is disinfected with tincture of iodine. If there are no fistulae, the foci are incised and eradicated. After removal of the diseased tissues, the cavity is tamponed with gauze moistened with physiological salt solution. After the hemorrhage has been stopped, the cavity is dried and filled with sterilized vaselin. Suture of the skin is but partial, so that the secretion may drain away. If no fistula is present and there is only an abscess to deal with, the procedure is the same: the abscess is opened and the cavity is scraped with a sharp spoon and filled with vaselin. Rinonapoli followed a similar procedure in five of his cases except that he did not disinfect the bone foci and he filled them with gauze saturated with vaselin. In all cases he obtained successful results, curing his patients in from four to six months. However, this drainage does not seem adequate. The author considers the introduction of gauze, as in osteomyelitis, harmful, since it prevents secretion and irritates the bony tissue. Vaselin itself drains so efficiently that it can be used without concern even in those cases in which the cavity has had a secondary infection. The use of vaselin alone does not require redressing of the wound, since, in the process of healing, the vaselin is forced out. Therefore, the bone is entirely unmolested, which is desirable for healing. It is the writer's belief that filling the cavity with vaselin is proper even if no fistulae are present. Vaselin then acts as a filling.

The need of filling bone cavities has always been recognized and various suggestions as to the ingredients have been offered. The principal reason for filling the cavity is to replace the defect with material similar to osseous tissue which, through osteoblastic activity, will supply the basis

for a quicker compensation of the defect. Secondly, the filling is supposed to restore the disturbed stability of bone and at the same time to act as a preventive to infectious agents in the cavity. A fault of all or most of these prescriptions for fillings has been the admixture of disinfecting materials. Such fillings naturally represent foreign bodies which irritate and cause reactions that end in elimination.

Fillings, as they were formerly employed, had one undeniably favorable result in cavities which were infected: they prevented the bone defect from filling with blood. Bearing this in mind, the author began to use vaselin chiefly to prevent formation of hematomata and to establish a continuous communication between the osseous cavity and the exterior. If the cavity can be kept from filling with blood, a means is at hand for preventing the increase of microbes upon favorable ground. Vaselin as a filling material has in this respect proved very successful. Bone tissue bears it exceedingly well because of its neutrality and non-irritability.

The following cases have been treated according to the method described:

Case 1. J. C., a boy, eight years of age, was admitted to our Clinic on November 8, 1934, with a history of having had pain since July 1934 in the lower part of the right forearm, which was swollen. The pain had continued day and night. An abscess had formed and had been opened and cleaned out in another hospital. Both incisions had drained for a long time and fistulae were present. The family history was negative.

Roentgenographic examination (Figs. 1-A and 1-B) revealed juxta-articular tuberculosis of the lower end of the right radius. The focus was irregular and oblong in shape. It was limited by the metaphysis and partly involved the metaphysis, the adjacent diaphysis, and the epiphysis. The disease had probably been present for a long time, although this could not be determined from the history.

On November 9 the lesion was eradicated according to the procedure described, followed by the application of a plaster-of-Paris bandage, with the hand in the functional position. The histological finding was tuberculous, caseous productive osteomyelitis.

The postoperative course was favorable; the patient was without fever and was discharged on the twelfth day. Six weeks later the wound was redressed. On the volar side was a smoothly healed scar and on the dorsal side, a granulating surface. This dressing was not disturbed for six weeks. At that time, both incisions had completely healed. Roentgenographic examination showed the areas of rarefaction to be filling up. Another plaster-of-Paris bandage was applied and left in place until March 3, 1935, when the roentgenograms (Figs. 2-A and 2-B) showed the lesion to be healed.

Fig. 1-A

Fig. 1-B

Case 1. J. C. November 8, 1934. Juxta-articular tuberculosis of the lower end of the right radius.

Case 2. M. P., a girl, three years of age, was seen in our Clinic

FIG. 2-A

FIG. 2-B

Case 1. J. C. March 3, 1935. Lesion healed.

in December 1934. The mother had given birth to the child out of wedlock and had nursed her for six weeks only. The mother suffered from pulmonary tuberculosis to which she succumbed when the child was two years of age. The first symptoms of the disease in the child had manifested themselves in the spring of 1934. In walking she inverted the right foot and limped slightly. In the summer of 1934, the outside of the left ankle began to swell. The child was treated in the Out-Patient Dispensary of another institution. A plaster bandage was not applied.

Roentgenographic examination at our Clinic showed the focus of the disease to be located in the right heel bone (as is quite typical in children) on the posterior and upper surface of the calcaneum. An abscess was present on the outside of the ankle.

The focus of disease was eradicated, the abscess was drained through a short incision, and a plaster-of-Paris bandage was applied. The diagnosis was confirmed histologically.

After the second dressing, three months later, the abscess healed with a smooth scar. The postoperative course was favorable; there was no fever. The area of the lesion filled completely after four and one-half months. Before complete healing took place, however, a new focus was found in the upper metaphysis of the tibia, which also involved a large part of the epiphysis. Again a subcutaneous abscess developed. Eradication was performed on February 20, 1935. The course was again favorable. Toward the end of May, the patient contracted scarlet fever and disappeared temporarily from our observation. In September 1935 the focus in the tibia had healed perfectly.

This case is particularly interesting because of the fact that healing was obtained in a comparatively short time, although we were dealing with a weak child with poor resistance.

In June, July, and September 1935, additional eradications of para-articular lesions in various localities were made in the manner described. In three cases large lesions of the femoral neck were found, which threatened to penetrate the joint. In these cases the eradication was made through a small opening in the greater trochanter. At the same time it was necessary to excise the sound part of the neck. The cavities were filled with warm vaselin and only a small opening was left for the outflow of blood. In each case a plaster-of-Paris spica was applied to the hip. The postoperative course in each case was satisfactory. In November 1935, check-up examinations of the patients showed healing of the wounds and an advanced degree of regeneration of the osseous tissue in the eradicated cavities.

In addition to these cases, eradications of para-articular lesions in the upper part of the tibia and in the outer condyle of the femur have been performed. The detailed history of these cases is not included because

only a short time has passed since the operations. Nevertheless, we consider all these cases to be healed and we feel ourselves authorized to affirm this because all the follow-up roentgenograms have revealed a rapid regeneration of the osseous cavities.

The difficulties encountered in treating localized bone foci are slight, however, as compared with those met with in cases of florid infection of articulations in which abscesses or fistulae have formed. Articulations cannot be opened by operation without endangering the patient. The focus of pus production is, therefore, unapproachable. There is no way of preventing the ample flow of secretion from the fistulae. An enormous secretion with its foul odor and offensive appearance requires frequent redressing which leads to infection of the fistulae. Although theoretically the rule is that dressings should be absolutely aseptic, practically this is not always possible. The fistulae and their surroundings can be kept without secondary infection only for a limited time, but the abscesses drain for months and even years. Mechanical cleaning and disinfection irritate the skin, no matter how carefully they are done. Bone tuberculosis, even when not infected, heals very slowly. An added infection causes the secretion, as well as the temperature, to increase. The patient loses appetite; his bodily resistance is lowered; he begins to fail; and not rarely he dies.

And what about closed abscesses? The physician works in constant fear of fistulae, constant fear of superinfection. Therefore, careful remote puncture through non-diseased tissue should be the procedure. Injections of various solutions which are supposed to thin out the contents of the abscess, as well as aspiration of the pus, are often not entirely successful. The fundamental fault of this procedure is the continued disregard of the basic principle in the treatment of surgical tuberculosis,—that the site of tuberculosis should be given absolute rest.

In our Clinic treatment in cases of closed foci where redressing would be necessary was given up until after immobilization had been accomplished by plaster splints. After the abscess had been cleaned out, the plaster dressing was reapplied. The more the abscess filled or the more profuse was the secretion through the fistulae, the more frequent were the redressings or punctures and the less certain was the success of the treatment.

These facts necessarily led to a consideration of how best to circumvent these obstacles. The first attempt at solving the problem was made by Solieri in 1912. He suggested the application of plaster-of-Paris bandages, regardless of the secretion of the fistulae. In brief, his procedure is as follows: extraction of the sequestra, puncture of the abscesses, rinsing of the abscess cavities and fistulae with Durante's solution, protection of the skin directly around the fistulae with astringent salve, absorption of the pus with a layer of gauze and cotton batting, and the application of plaster-of-Paris dressings. In 1929 he reported that since 1912 he himself had treated a total of thirty-two patients. Of these, twenty-four were cured; four had died; and in four cases the treatment

was unsuccessful. Other authors who have reported the successful use of Solieri's method, either in its original or modified form, are: Calcagni, Capecchi, Conti, Mannarini, Marinescu, Benci, Tedeschi, Kofmann and Tarlo.

Complete rest in plaster and autovaccination produced by the accumulation of pus on the skin are factors which, in accordance with the opinions of these authorities, *act favorably on the healing of the fistulae and the primary focus. No consideration whatsoever is given to the question of secondary infection, which should not be disregarded.* Thus one can explain the considerable maceration of the skin with pus, but, according to the Italian authors, this maceration is favorable, so that some of them make no attempt to prevent it. They believe that the most successful results are obtained by vaccination of the diseased skin with pus from the wound itself. Experience has taught us that cutivaccination in tuberculosis does not work favorably. Unfortunately, the author's information is based only on reports, since all scientific works which deal with Solieri's method have appeared in Italian periodicals which are not available in Czechoslovakia. Therefore, the writer does not know to what extent the skin is covered with salve and what kinds of salve are used. The author does not wish *to deny the importance which the Italian authors ascribe to the continuous contact between pus and the irritated skin; however, he certainly prefers to see the skin non-macerated* rather than macerated. The writer does not know how intensive the maceration is when the skin is covered with astringent salves, but, judging from the work of Lačný, it is very considerable. The appearance of the skin was such that, in combination with the bad odor and other unfavorable circumstances, it made him abandon and condemn Solieri's method which he tried in four cases. Lačný, however, made the mistake of not trying to maintain the time intervals between individual dressings as Solieri had prescribed. Lačný is also the only author who was disillusioned with Solieri's method. In our judgment, also, Solieri's method has its unfavorable aspects. The gauze is put directly on the opening of the fistula and covered with a soft dressing, purposely thin. The plaster is modelled to fit closely, so that either the secretion cannot drain at all or else it drains with difficulty. This explains the occasional rise in temperature noticed by other authors in using Solieri's treatment.

The following method seems to the author to avoid the disadvantages of Solieri's treatment: The skin is first disinfected over the largest possible area with tincture of iodine. *If a cold abscess is present, an incision, from two to three centimeters in length, is made.* Through this opening a spoon is inserted, the walls of the abscess are thoroughly scraped, and the cavity is tamponed with gauze moistened with a physiological salt solution. After the bleeding has been stopped, the cavity is filled with vaselin in semi-liquid form, partially warmed. The semi-liquid vaselin adheres to the walls of the cavity and forms a perfect drain. The skin about the wound is covered with a thick layer of vaselin, so that there remains

uncovered in the vicinity of the wound not a spot which the pus could touch during the ensuing weeks. Any unprotected area would assuredly be macerated by the pus. Especial emphasis should be placed on the fact that it is unwise to spare vaselin when coating the skin. Over the wound is placed a layer of sterilized gauze and cotton batting, preferably thicker than an ordinary dressing. A thick layer of covering material soaks up the vaselin and enables the pus to drain into the upper layers which are to absorb the pus. A well-molded plaster-of-Paris dressing is then applied in which the adjoining two articulations are included.

If there are fistulae near the diseased articulation, the openings are merely widened and the entire fistulae are scraped. The procedure which follows is the same as that already described. It is not advisable to change the plaster-of-Paris bandage before the end of six weeks.

The suggested modification of Solieri's method seems to the author to be very favorable for the following reasons:

1. It takes into account the possibility of secondary infection. The sterilized covering of the fistula forms a closed space under the plaster cover for the gathering pus. Secondary infection cannot penetrate the plaster dressing. The question of infection or non-infection of the site of tuberculosis seems of primary importance.

2. If bone or articular tuberculosis, pyogenically infected, is encountered, the vaselin ensures as perfect a drainage as can be desired. It is necessary to drain without gauze.

3. In this method of treatment there is no danger of retention of pus; therefore, even in foci infected pyogenically, one may employ the most important weapon in the treatment of bone tuberculosis,—perfect immobilization in a plaster-of-Paris bandage.

4. After the festering wounds have been filled with vaselin, a rather slight amount of pus has been noted under the plaster-of-Paris bandage. The secretion is usually most marked during the first week and the dressing is soaked through. During the second week the secretion is less and it gradually decreases in amount. This fact naturally has more bearing on the pyogenically infected wounds. One certainly cannot compare the secretion which is encountered during the dressings with that previously met with when redressing was done every other day. In so serious a disease, the great decrease in albumin caused by hyperproduction of pus is certainly not to be disregarded.

It seems to the author that rinsing and various antiseptic solutions are improper and dangerous methods of treatment. Certainly, in most cases, such a disinfectant rinsing does not reach any farther than the abscess cavity; the focus is reached only partially by the application of pressure, which should not be used. It is well known that, because of their alkaline reaction and other reasons, certain abscesses are unfavorable ground for the growth of Koch's bacillus. Bacilli are rarely found in abscesses; rinsing, therefore, is superfluous and the writer cannot agree with Solieri.

A frequent objection to the healing of wounds by confinement in plaster-of-Paris dressings is the bad odor. True, the odor of the bandage, which seals the pus for a long time, is very offensive. It annoys those about the patient, but seldom troubles the patient himself. It is the only serious objection to this treatment. However, if the treatment is benefiting the patient, the bad odor ought not to be a cause for removal of the plaster-of-Paris dressing. It is probable that some other ingredient may be found which, when mixed with vaselin, will neutralize the odor. Löhr combined cod-liver oil with vaselin and attributed his successful results to the healing properties of the oil. However, although cod-liver oil somewhat neutralizes the odor, the author has observed no better results from the use of this mixture than from pure vaselin. In fact, he has often noted maceration of the skin following the application of cod-liver oil, which is not the case when vaselin alone is used.

It is unquestionably advantageous to give vitamins during bone diseases, but they should be given by mouth. It seems to the author very unwise to risk infection by filling the wound with unsterilized cod-liver oil. Löhr contends that cod-liver oil is practically sterile and that it kills pyogenic flora. However, according to the very thorough and careful experiments carried out by Patočka and Görtzen, cod-liver oil, paraffin oil, and vaselin have not the slightest bactericidal properties.

The following cases have been treated according to the modification of Solieri's procedure which has been described.

Case 3. V. M., a girl, aged fourteen years, was admitted to our Clinic on November 7, 1934. At the age of nine, she had had inflammation of the left hip. Two and a half years later, healing by ankylosis took place in a position of flexion and adduction. In October

Fig. 3-A

Fig. 3-B

Case 4. B. M. Advanced destruction of the olecranon and of the head of the humerus.

1934 the patient had fallen and had injured the left trochanter, and in November pain had developed.

On admission, examination showed the region near the greater trochanter to be swollen. The skin was reddened and fluctuant. Roentgenographic examination revealed a large lesion in the trochanter.

Diagnosis: Ankylosis of the left hip; recurrent coxitis; a cold abscess in the region of the greater trochanter.

A short incision was made and about 200 cubic centimeters of pus was drained from the abscess. The carious cavity was curetted and filled with vaselin. A plaster-of-Paris bandage was then applied.

The postoperative course was uneventful; there was no fever. Three months after operation, the patient had gained in weight and her general condition was good. The incision had healed with a smooth scar and the skin was dry. The contour of the trochanter was sharply defined. A roentgenogram showed that the area of rarefaction was beginning to fill. In April 1935 the focus in the trochanter had filled, so that it was possible to perform a subtrochanteric osteotomy of the femur to correct the malposition of the limb. In the middle of May a short plaster-of-Paris bandage, reaching to the knee only, was applied, and the patient was discharged. Weight-bearing was allowed

Case 4. B. M., a woman, sixty-three years of age, was admitted to the hospital on December 11, 1934. She gave a history of having been in good health until five years previous to admission, when the right elbow joint had become swollen and attempts to move it had resulted in great pain. Treatment had consisted in the application of a plaster-of-Paris bandage, but this had been allowed to remain for about two months only. The pain had been bearable and there had been only occasional fever. Since the beginning of 1934, she had grown considerably worse,—the joint had swollen and on the outer side a fistula had formed which drained pus. The patient ran an evening temperature. Her husband had died of tuberculous peritonitis.

On admission, the following findings were noted: obliteration of the contours of the joint, doughy swelling on the outer side,

Fig. 4-A

Case 4. B. M. Resection of the humerus above the trochlea at about the middle of the coronoid fossa.

Fig. 4-B

Case 4. B. M. Resection of the ulnar joint surface, the olecranon, and the head of the radius.

FIG. 5-A

FIG. 5-B

Case 4. B. M. Showing range of motion possible after operation.

and a small fistula from which thin pus drained. Passive motion was very painful and the range was as follows: extension, 110 degrees; flexion, 90 degrees.

Roentgenographic examination (Figs. 3-A and 3-B) disclosed advanced destruction of the olecranon and of the head of the humerus.

Diagnosis: Tuberculosis of the right forearm with fistula.

At operation on December 12, 1934, the right elbow joint was exposed by Farabeuf's incision. A resection of the humerus above the trochlea, at about the middle of the coronoid fossa, was then performed. Of the forearm bones, the entire joint surface of the ulna, with the olecranon and the head of the radius, was resected,—the typical resection of Ollier. (See Figures 4-A and 4-B.) In addition, the nearby diseased soft tissues were removed. The space between the ends of the bones was filled with vaselin; the muscles and tendons were sutured; and the skin was left with an opening above the joint for drainage. A plaster-of-Paris bandage was applied with the arm in 100 degrees of flexion.

The postoperative course was very favorable. The pain disappeared. After six weeks the dressing was removed. The skin had healed, and active exercises were begun. Three months after the operation, following daily massage and exercise, a very adequate range of motion resulted (Figs. 5-A and 5-B). Flexion, extension, pronation, and supination were possible to an almost normal degree and without pain. In May 1935 the patient was able to carry light objects with the arm which had been operated upon.

CASE 5. B. C., a male, twenty-four years of age, was seen in October 1934 with a history of having suffered an injury in the region of the right hip in December 1933. There had been no immediate consequences. On April 6, 1934, he had suddenly felt ill, had fainted, and had fallen down. Three weeks later, in the hospital where he had been taken care of, an abscess had been found in the right inguinal region, extending as far as the femur. The abscess, which was evidently cold, had been opened by two wide incisions,—one in the inguinal region, the other on the exterior side of the thigh. From the draining wounds, the secretion of pus had been abundant. The temperature, which at first had been subfebrile, became very high after the occurrence of secondary infection. The family history was negative.

When seen by the author, the patient's condition was very unfavorable. The

FIG. 6

Case 5. B. C. Showing condition in March 1935, when the wound was first redressed.

temperature was above 39 degrees centigrade. The patient was pale and very much exhausted by fever. The right hip was swollen considerably. The most striking feature was the swelling in the region of the trochanter, which was indurated and oedematous. In the middle of the incision in the right groin was located a craterlike fistula from which a large amount of yellowish-gray, foul, viscid pus drained. The area surrounding the fistula was reddened. From a similar fistula on the outer side of the thigh large quantities of pus were also draining.

Diagnosis: Inflammation of the right hip with fistulae, due to secondary infection; osteomyelitis of the head and neck of the femur; pathological dislocation of the right hip.

Roentgenographic examination (Fig. 7) confirmed this diagnosis.

On November 11, 1934, under anaesthesia, a trepanation of the femur was performed, close to and below the trochanter. Through an adequate opening, an eradication of the disease in the neck and head was successfully accomplished. The incision was left open, and the cavity and soft parts were filled with vaselin mixed with cod-liver oil after the method of Löhr. The fistula in the inguinal region was excised and filled with vaselin. Staphylococcus albus was found in the pus. On the fifth day after the operation, the temperature was lower, and later reached only subfebrile levels. It remained in this rather satisfactory condition until January 11, 1935, when it again rose to 39 degrees centigrade.

On January 25, 1935, another operation was performed. The incision in the inguinal region was widened and that on the outer side of the thigh was opened again and a new incision made on the ventral side with a connection between them, so that adequate drainage of the secretion was thus guaranteed. The bones were not incised. The cavities were filled with vaselin and cod-liver oil. The temperature remained high during the first week after the operation and then became subfebrile.

When the wound was redressed early in March, the bandage was found to be thoroughly soaked and the odor was very offensive. Although the incisions were nearly filled with granulations, they secreted considerable pus. See Figure 6. The skin of the upper half of the thigh was greatly macerated. This condition [illegible] that the mixture of vaselin and cod-liver oil is not a suitable covering for the skin, for it irritates rather than protects. A dressing with pure vaselin was then applied and left undisturbed until May 23, 1935. At this time it was [illegible]

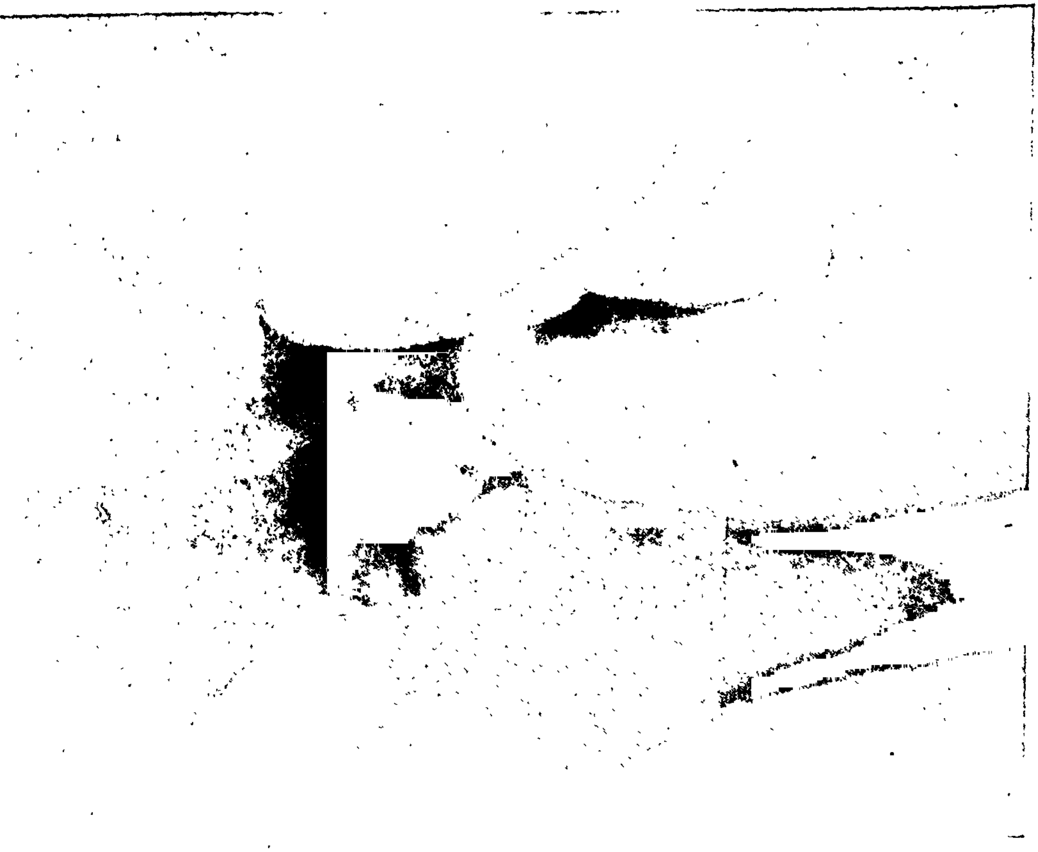

FIG. 7

Case 5. B. C. Pathological dislocation of the right hip, due to osteomyelitis of the head and neck of the femur.

FIG. 8

Case 5. B. C. July 28, 1935. Showing ankylosis of the right hip joint and recalcification of the head and neck. An irregular shadow of lipiodol may be seen within the pelvis near the head.

Fig. 9

Case 5. B. C. July 28, 1935. The incisions have healed with smooth scars.

considerably decreased. The patient had gained weight and felt well. The maceration of the skin had disappeared. The incisions in the inguinal region and on the ventral side had healed. On the outer side of the leg there still remained a small granulating surface.

Another bandage was applied, which was not changed until July 28, 1935. At this time all of the incisions had healed with smooth scars. (See Figure 9.) On the same day roentgenographic examination (Fig. 8) showed ankylosis of the hip joint in quite good position and advanced recalcification of the head and neck. Signs of the eradication were evident only at the trepanation aperture near the trochanter. In the pelvis, near the head, was visible an irregular shadow of lipiodol.

Case 6. J. M., a male, eighty years of age, was admitted to the Out-Patient Dispensary in February 1934, because of swelling of the right ankle joint. The swelling had first become apparent after an accident in July 1933. It did not disappear even after a long period of immobilization and the application of Priessnitz dressings. In September 1933 the patient had been treated with hot baths, because the illness had been taken for a uratic affection.

Diagnosis: Tuberculosis of the right tibio-astragalar joint with fistula.

A plaster-of-Paris bandage, with an opening, was applied and through this opening the dressing was changed. In November 1934 the treatment which has been described was started. On July 2, 1935, the fistula was found to have healed.

In addition to the cases reported, eight similar cases are now being treated. In all of these, great improvement has been noted after the first dressing.

Note: Much of the material in this article, as well as the cuts included, appeared in *Slovanský Sborník Ortopedický*, X, 54, 1935, and is reproduced by permission of the editor of that journal.

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ARTHRITIS AS A TEACHING PROBLEM *

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For many years arthritis has been one of the major problems with which the orthopaedic surgeon has been called upon to deal. However, it is not the treatment of arthritis that is the concern of this paper, but our final Hippocratic duty in regard to it,—namely, to train the oncoming generation of students to meet and, perhaps, to solve this terribly baffling puzzle. Medical literature is witness to the variety and many-sidedness of the conditions we glibly group under the term "arthritis", which render it a veritable wilderness to the unexperienced and unguided student. With so indeterminate a subject and with so little time to waste in teaching, is it not important to put to ourselves four primary questions for honest answer before we go before our students or even before our peers?

I. What Is Arthritis?

Each one would give a different answer probably, and that answer would be the foundation of his teaching. The answer which seems most honest to the author is that, when the joint inflammations of *known* etiology have been excluded, arthritis is just good old-fashioned rheumatism, a symptomatic term honest in its vagueness and lack of pseudo-scientific presumption. That the various joint manifestations in arthritis —pain, swelling, heat, osteophytes, etc.—are symptoms of some systemic disorder affecting the individual as a whole is a fact which anyone who has seen a real case of Still's disease, rheumatoid arthritis, arthritis deformans, or gout cannot escape realizing. Why is it that in mild or early cases we fail to recognize this same fact,—namely, that we have a systemic illness to deal with and not just a sore joint or two? Yet one invariably gets the impression in meetings or clinics that arthritis is a *disease* in itself rather than a symptom probably common to a number of infectious diseases and metabolic disturbances. Our position in regard to arthritis is comparable to that of the doctors of a century ago with regard to fever with its various clinical classifications,—such as hectic, puerperal, tertian, breakbone, etc. An honest statement of the protean character of arthritis and the difficulties arising therefrom will prove much more enlightening and stimulating to questioning students than artificial classifications and halting explanations.

II. Who Is to Teach Arthritis?

Having taken the ground that arthritis is merely a joint manifestation of an underlying systemic condition, to be consistent one would have to admit that the physician rather than the orthopaedic surgeon should

* Read at the Annual Meeting of the American Orthopaedic Association, Philadelphia, Pennsylvania, June 6, 1935.

be the one not only to treat it but to teach it. Practically, this does not work out well for two reasons: first, the medical staff of a university already has the major teaching burden and is put to it to cover adequately the very wide field of general medicine; second, the medical wards cannot be filled with such long and chronic cases as arthritis, which means that there is a paucity of clinical material at hand for the Medical Service to use in teaching.

If it is not to be the Medical Staff, then, of necessity, the Orthopaedic Staff seems to be the victim. Our teaching field is smaller and we should welcome this opportunity to make an excursion into the medical territory, to revert again to our primary rôle of physicians, and to escape temporarily from the narrow confines of a surgical specialty. We certainly have a wealth of teaching material in our clinics and wards and in those special institutions which we serve that are separate but allied to the central teaching hospital. Every Orthopaedic Children's Hospital has its quota of Still's disease, and a "Home for Incurables" or a Chronic Hospital can supply a wealth of tragic arthritic end results. It should be our constant endeavor, however, to secure the support and help of the medical staff in the teaching as well as in the treatment. In this subject we ought to regard ourselves as liaison officers between the armies of medicine and surgery.

III. Where Is Arthritis To Be Taught?

There are four ways to present problems to the student: (1) in lectures; (2) in ward classes; (3) in the dispensary clinic; and (4) in the literature and in the laboratories.

For our purpose each has its special use. One or two lectures seem to be definitely needed in order to present the complexity of the problem, to tell the story of progress made, to present the fundamental pathological lesions *in vivo* and *in vitro*, and to show a few cases illustrating the great variations encountered. Ward classes give us an opportunity for much greater detail of examination and allow us to present the necessary studies and laboratory aid required. They also give us a chance to emphasize the individuality of each case and to direct the student's attention to the multitudinous factors which play a rôle in the patient's illness. Both lectures and dispensary teaching deal too broadly or too hurriedly with patients to fasten this principle in the student's mind. However, the dispensary, with its hurly-burly and volume, gives us a chance to see the early mild case as well as the old cripple, and in this way adds the proper depth of perspective to the pictures which we wish the student to carry away.

Finally, how shall we guide these students in literature and in research? This is perhaps the hardest problem, as the literature is so muddled by diverse terminology and the research problem is so complex that adequate direction is almost impossible. The author's advice is for the seriously interested student to read everything and believe nothing.

If a man reads widely with reference to arthritis, he will be made aware of many theories, explanations, treatments, and cures, but let him beware lest some therapeutic Circe enchant him and enslave his errant curiosity in the mental sty of a fixed idea. Only by critical observation and careful analysis will our riddles be solved, so a staunch skepticism must be maintained in the presence of the printed word. Independent laboratory research should be discouraged until such a time as observation and clinical experience have given the beginner some lead which he himself is keen to test and follow. There is no doubt that a great deal of our confusion has arisen from the desire of the laboratory worker to find something which can be published, rather than to find the explanation for himself of some suggestive clinical observation which he has made.

IV. How Is the Subject To Be Taught?

It can be taught dogmatically, in an *ex cathedra* manner, but in the average medical school this is not safe. The professor is too vulnerable in this particular subject to assume omniscience, and the established facts about which one can be dogmatic are few and far between.

It can be taught as if one were an advocate, pleading the righteousness of a theory or of a method. But this, too, is dangerous unless one tempers one's enthusiasm with an occasional candid reflection that after all one's pet thesis may be wrong, and an innocent organism may be lynched or an inconsequential joint may be twisted for no permanent scientific gain.

One can teach it as an experimenter, a sound and honest but not very tangible way to present a complex subject to the student, the danger being that the student will get only a narrow viewpoint of a large subject.

Or, one can expound it as a philosopher, viewing the subject broadly and dispassionately, pointing out where one can distinctive and helpful land marks (both clinical observations and experimental findings), following the leads of theories as far as one can see clearly, examining the effects of various types of therapy advocated at this clinic and that, suggesting a possible trail to follow in future experimentation, but, above all else, avoiding the semblance of speaking with authority on a finite disease.

In conclusion, the author wishes to present for consideration a scheme which so far he has found more satisfactory than any other in conveying to the student his conception of arthritis.

This scheme likens the arthritides to a spectrum, the red end being represented by acute rheumatic fever and the violet end by gout, with a complete but gradual variation in shade and type in between. Certain particular bands, like the post-tonsillitis, subacute arthritis in the reddish area of the spectrum or the bluish osteo-arthritic group, stand out boldly it is true. As long as one has to deal with rheumatism on the basis of clinical findings there can be no accurate hard and fast classes, so that the colors of the spectrum, shading from one into the next without any line of demarcation, give us a graphic method of putting our conceptions before

TABLE I
A GRAPHIC METHOD OF CLASSIFYING THE ARTHRITIDES

Clinical Manifestations	Spectrum	Type of Arthritis
	Infra-Red	
No resultant joint change	Red	Acute rheumatic fever
Joint changes of proliferative type		Acute infectious arthritis—relation to focal infection clear
	Orange	Subacute infectious arthritis—relation to focal infection indefinite
		Still's disease
	Yellow	Rheumatoid arthritis
Atrophy		Atrophic arthritis
		Arthritis deformans
Mixed changes	Green	Villous arthritis
		Serum or allergic arthritis
		Arthritis associated with endocrine disturbances
	Blue	Arthritis associated with chronic traumatization
Degenerative type of joint lesion		Marie-Strümpell arthritis
		Hypertrophic arthritis
	Violet	Osteo-arthritis
Crystalline deposits		Gout

the students without artificially separate categories. The student comes for help with a jumble of terms in his mind, and by means of this method we try to fit these terms into one another and into our spectrum.

Not only is this method convenient for assorting cases when first seen, but it allows for the chameleonlike changes observed in individual cases as they run their course and vary from month to month,—such as the infectious type which progresses slowly to crippledom and atrophy. Mixed conditions often occur, and, by mixing shades of simple conditions, one can match the complexion of any individual case. The spectrum also brings out the protean character of arthritis mentioned earlier, one of the facts that it is important to impress on students.

TREATMENT OF MALUM COXAE SENILIS, OLD SLIPPED UPPER FEMORAL EPIPHYSIS, INTRAPELVIC PROTRUSION OF THE ACETABULUM, AND COXA PLANA BY MEANS OF ACETABULOPLASTY*

BY M. N. SMITH-PETERSEN, M.D., BOSTON, MASSACHUSETTS
Chief of Orthopaedic Service, Massachusetts General Hospital; Clinical Professor of Orthopaedic Surgery, Harvard Medical School

In February 1935 a patient, aged fifty-five, was admitted to the Orthopaedic Ward of the Massachusetts General Hospital with the diagnosis of "bilateral intrapelvic protrusion of the acetabulum". The case was discussed on ward rounds and the general opinion was that nothing could be done for this patient, and that she would have to adapt her life to the hip-joint condition. This did not seem a constructive attitude, and the patient was allowed to stay on the ward in the hope that some operative procedure might be developed which would give her relief from pain.

The question to be answered was this: "What is the source of this patient's pain?" The answer was: "The impingement of the femoral neck on the anterior acetabular margin". Such impingement would result in "traumatic arthritis" with characteristic changes of the joint surfaces as well as of the synovia. Since the joint surfaces have no nerve endings, their function in itself cannot be the source of the pain; as they slide over one another, even though the hyaline cartilage is markedly thinned, they will not give rise to symptoms. What does give rise to pain? The impingement of two surfaces—one covered by synovia, the other by cartilage—will give rise to congestion of the synovia, synovitis, and, because of periosteal irritation, hypertrophic changes.

The following analysis gave us the answer to our problem: If we could eliminate this impingement, we should be able to eliminate the resultant reactions and, therefore, pain. To eliminate impingement two regions may be attacked,—the neck of the femur and the anterior margin of the acetabulum. To eliminate impingement by a plastic procedure on the neck of the femur would be impossible, since this would sacrifice too large a portion of the neck. (See Figure 1.) What would be the effect of removing the anterior wall of the acetabulum? By sacrificing a small portion of this structure, a wide range of motion would be gained. This, then, seemed to be the answer to our problem. The patient was informed that the operation had never been performed before, but that it did offer a chance of success. She accepted the operation willingly. In four weeks she left the hospital walking, and in four months she returned to her work

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, St. Louis, Missouri, January 14, 1936.

as a housekeeper, free from pain and without a limp.

The success in this case naturally suggested that the same procedure might be successful in other types of cases in which similar impingement was present. Malum coxae senilis came to our minds first. Since the operation was one that did no harm, we felt justified in applying it to a condition for which we had no adequate treatment. It has now been performed in eight such cases and the response has been so favorable that we feel free to publish a description of the procedure, in spite of the fact that it has been used for too short a time to enable us to give "end results".

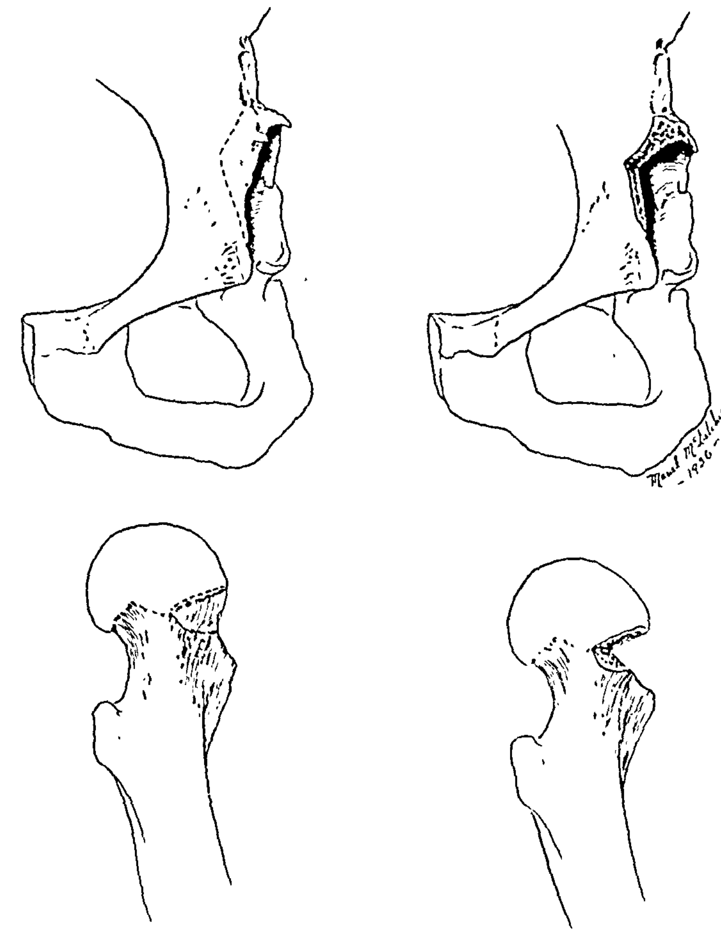

FIG. 1

Diagrams demonstrating the amount of bone which must be removed from the acetabulum or from the neck of the femur in order to produce the same improvement in the range of motion. This amount of bone may be easily spared from the acetabulum, but not from the neck of the femur.

The procedure has also been applied to two cases of "old slipped upper femoral epiphysis" with impingement of the projecting anterior femoral neck on the anterior acetabular margin. In each case there has been improvement in function and relief from pain.

Fractures of the acetabulum with intrapelvic displacement of the head of the femur present the same mechanical problem as did the first case,—that of intrapelvic protrusion of the acetabulum. Consequently this operative procedure might be very effective in relieving pain and restoring function in this type of case.

OPERATIVE TECHNIQUE

The incision extends along the anterior third of the iliac crest to the anterior superior spine, then curves slightly medially along the lateral border of the sartorius muscle. (See Figure 2.) Immediately inferior to the anterior superior spine one finds the plane of division between the sartorius and the tensor fasciae femoris. The femoral fascia is incised

along the lateral border of the sartorius, exposing the direct head of the rectus femoris. By sharp and blunt dissection the attachment of the direct head of the rectus femoris to the anterior inferior spine is defined.

The next step (Fig. 3) is to identify the plane of division between the iliopsoas muscle and the proximal portion of the reflected head of the rectus femoris; the latter takes origin from the anterior acetabular wall as well as from the anterior capsule. The iliopsoas muscle is retracted mesially (Fig. 4), exposing the anterior intrapelvic wall of the acetabulum. In order to obtain a better exposure of the lateral portion of the acetabulum, the tendon of the direct head of the rectus femoris is divided, leaving sufficient tendon attached to the anterior inferior spine to allow for suture. When the distal portion of this muscle is retracted, the reflected head of the rectus comes into view, partly fused with the anterior capsule, partly attached to the anterior acetabular margin. This is dissected free and retracted laterally with the direct head of the rectus femoris.

By the procedures described sufficient exposure of the anterior acetabular wall is usually obtained, but in some cases the iliopsoas muscle remains too taut to be retracted. In these cases it is advisable to reflect subperiosteally the origin of the sartorius and the abdominal oblique muscle from the anterior crest of the ilium, exposing the anterior portion of the iliac fossa. The iliacus may then be reflected subperiosteally down to the upper margin of the anterior acetabular wall, but at this point the periosteum is divided along the line of the intended osteotomy.

The above procedures allow for retraction of the iliopsoas muscle and of the sartorius mesially, and of both the direct and the reflected heads of the rectus femoris, and of the tensor fasciae femoris laterally. If the retraction mesially of the iliopsoas muscle is found difficult, the hip may be flexed, adducted, and externally rotated; by this procedure, the iliopsoas becomes relaxed and consequently may be retracted more easily. (See Figure 5.)

The next step is the osteotomy of the anterior acetabular wall; this may be done with

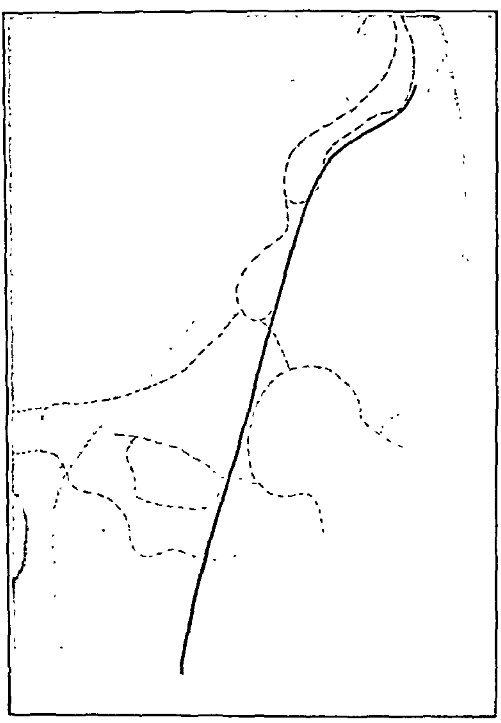

FIG. 2

The incision extends along the anterior third of the ilium and curves mesially along the lateral border of the sartorius.

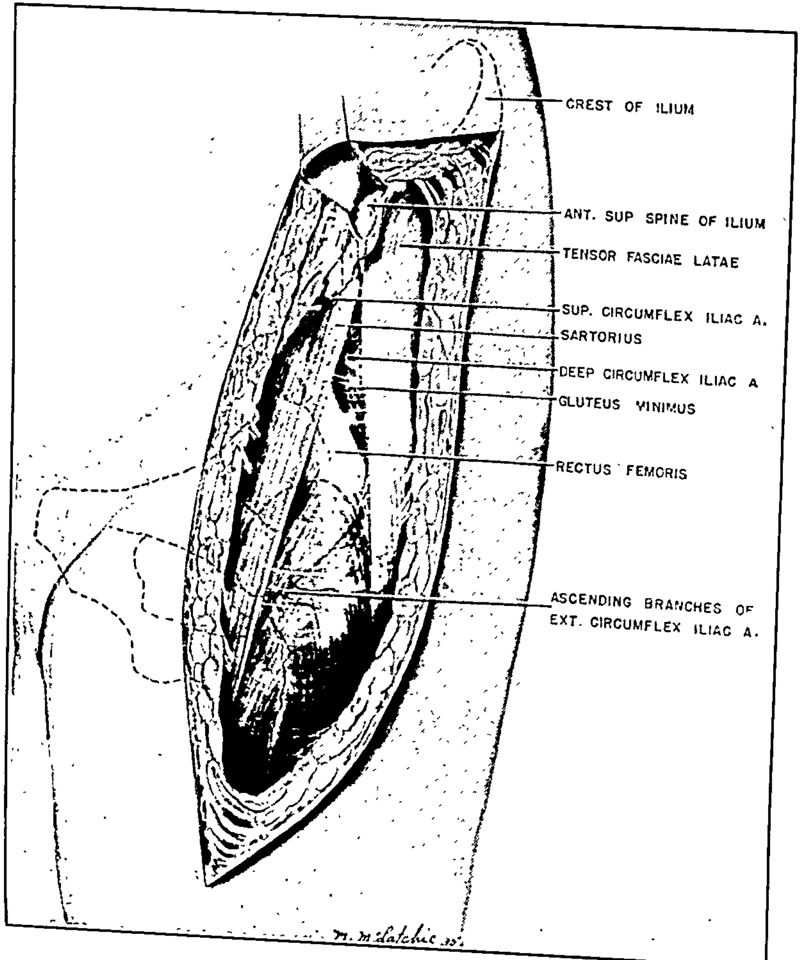

FIG. 3

Exposure of the anterior superior spine, of the lateral border of the sartorius, and of the mesial border of the tensor fasciae latae. Between these muscles is a compartment of fat with the rectus femoris as its floor.

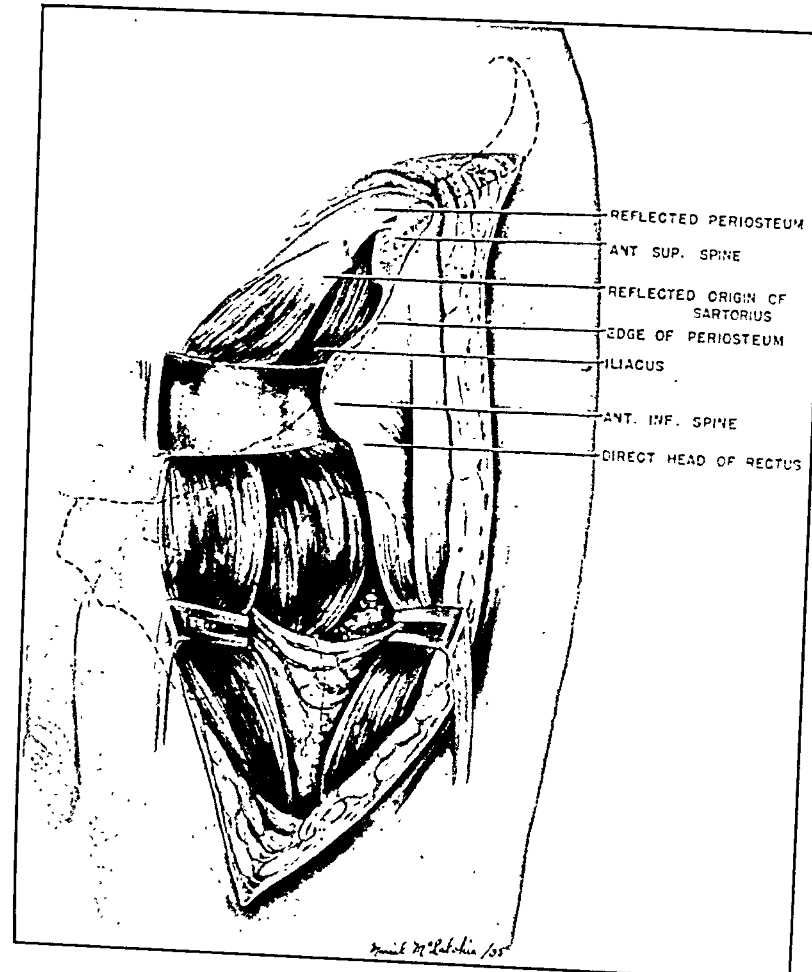

FIG. 4

Reflection of the abdominal oblique, sartorius, and iliopsoas muscles mesially, exposing the anterior aspect of the hip joint.

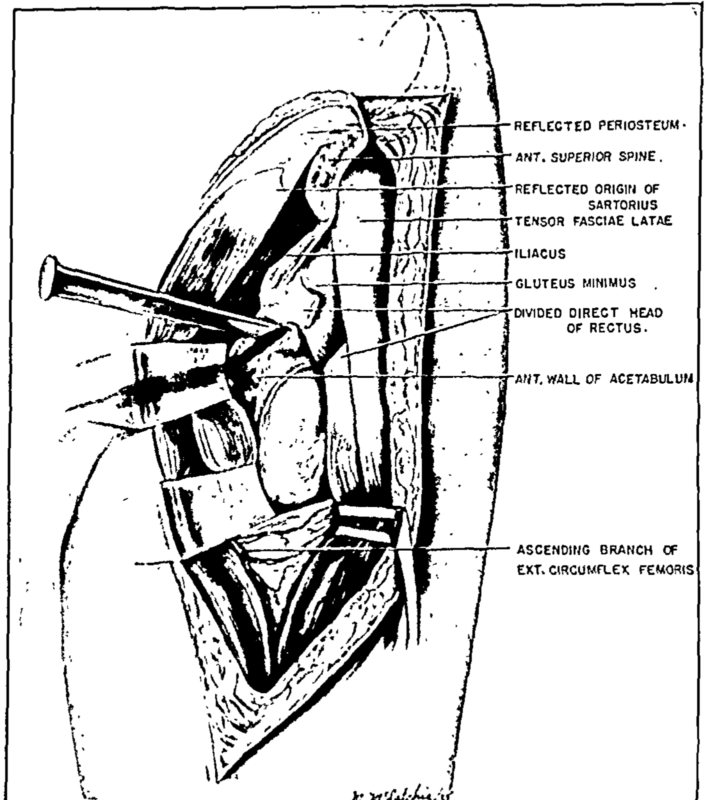

FIG. 5

Showing the line of osteotomy of the anterior acetabular wall immediately below the attachment of the direct head of the rectus femoris.

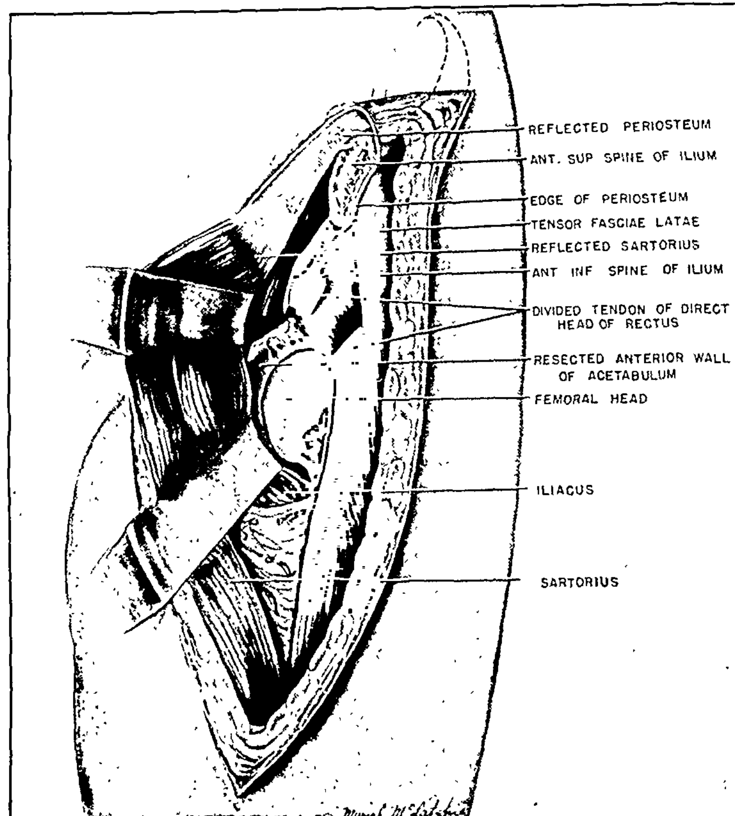

FIG. 6

Result of plastic procedure: exposure of the mesial portion of the femoral head and of the anterior femoral neck.

a thin osteotome or gouge. The osteotomy starts just below the attachment of the direct head of the rectus femoris and is carried mesially a distance of approximately an inch and a half and is then curved inferiorly down to the cotyloid notch. As soon as the fragment thus outlined becomes mobile the anterior superior capsule is incised down to the region of the distal neck. It is also incised inferiorly from the cotyloid notch along a line just proximal to the capsular attachment to the neck of the femur. (See Figure 6.) When the anterior acetabular wall with its attached capsule is lifted out, there is obtained a beautiful exposure of the articular surface of the head of the femur and of the anterior aspect of the neck.

By moving the hip in flexion, extension, abduction, and internal rotation, the surgeon now determines if the plastic procedure has been sufficient. If not, further excision of the superior acetabular margin and of the superior anterior capsule is done. The surgeon must be radical in performing this plastic procedure, but he should not remove so much of the superior aspect of the acetabulum as to allow the head of the femur to become displaced anteriorly. Of this there is relatively little danger, since hyperextension is rarely obtained and this is the motion which would allow the femoral head to dislocate.

The procedure follows structural planes throughout and consequently

Fig. 7

Preoperative roentgenogram showing definite protrusion of the acetabula, more marked on the left than on the right.

FIG. 8

FIG. 9

there is little or no shock. The two blood vessels encountered are the deep iliac circumflex and the ascending branch of the internal femoral circumflex. The former is easily eliminated; the latter sometimes gives rise to a little difficulty because of its extensive ramifications in the fat anterior and inferior to the hip joint. Furthermore, it is accompanied by motor branches from the femoral nerve.

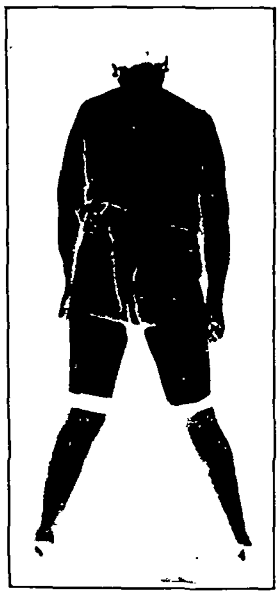

FIG. 10

The closure of the wound is very simple indeed. When the retractors are removed the iliopsoas drops back into place over the anterior aspect of the head and neck of the femur. The direct apposition of the posterior surface of this muscle to the anterior aspect of the head and neck of the femur is of great advantage,—two moving surfaces are very much less liable to form adhesions to one another than are two surfaces in more or less constant apposition, such as would be true of the capsule and of the underlying joint surface. The direct head of the rectus is sutured to its origin, and the superficial portion of the wound is closed in layers.

Postoperative convalescence is remarkable because of the relative absence of pain. The patient complains of soreness, but rarely of acute pain. The extremity is suspended with five pounds of traction, simply to overcome muscle spasm and thereby to diminish pain. The position should be one of extension with maximum abduction and maximum internal rotation. At the end of two weeks the patient is allowed up on crutches and, as a rule, he leaves the hospital at the end of three weeks; the maximum period of hospitalization is four weeks. He is taught exercises which he thoroughly understands by the time he leaves the hospital and which he carries on at home.

As already stated the main effect of this procedure is relief from pain; however, there is also considerable improvement in function. The in-

FIG. 11
Preoperative roentgenogram showing proliferative changes with thinning of the joint cartilage.

creased function is the direct result of the removal of the acetabular wall, thus preventing impingement. If the anterior femoral head and neck are very prominent, it may at times be advisable to do a plastic operation on these as well as on the acetabulum. There is no danger of new bone formation or exostoses as a result of this procedure, since mechanical interference has been eliminated and since medullary bone is in apposition to the moving posterior surface of the iliopsoas muscle. The removal of the anterior capsule is probably an important factor in eliminating pain, because of its sensory innervation. It is important to remove sufficient capsule, including the Y ligament of Bigelow, to diminish the chances of adhesions and of scar formation. Another point to be emphasized in the technique is this: The acetabular wall should not be exposed subperiosteally, but its periosteum should be removed with it. This will tend to prevent new bone formation.

FIG. 12
Postoperative roentgenogram. The line of osteotomy of the acetabulum is indicated by arrows.

In one case the iliopsoas bursa was encountered. It was distended and inflamed, and unquestionably had been a source of pain.

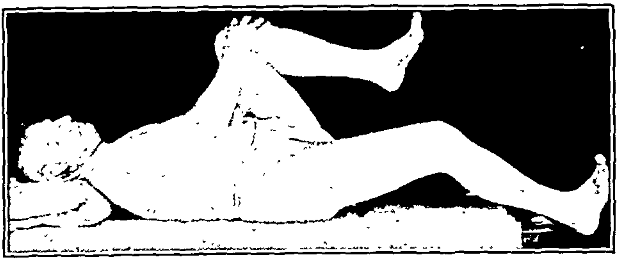

FIG. 13

CASE REPORTS

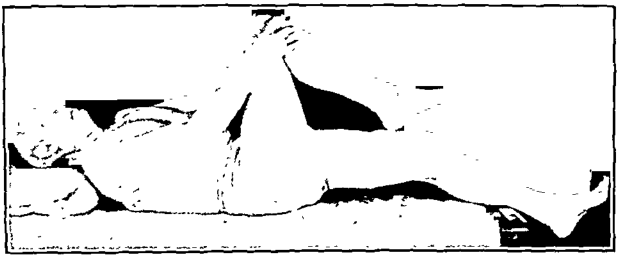

FIG. 14

The first case treated by this operative method was a case of "bilateral intrapelvic protrusion of the acetabulum" (Fig. 7). The patient was a woman, fifty-five years of age, who for months had been disabled for her occupation as a housekeeper. She was in pain lying in bed, sitting, standing, and walking. As a result of the operation she was able to return to work, free from pain and without even a limp. The postoperative range of motion was definitely but not markedly increased. Figure 7 shows very definite protrusion of the acetabulum on the left and the same condition, but to a lesser extent, on the right. The postoperative roentgenogram shows no essential change. Ten months after the operation function was as follows: complete extension (Fig. 8), flexion to 90 degrees (Fig. 9), and a perfectly definite amount of abduction (Fig. 10).

As has been stated in the introduction, the success in the above case led us to apply it to cases of malum coxae senilis.

FIG. 15

The first case was a man of fifty-eight, whose occupation was that of a brakeman. He had had symptoms from the right hip for a period of years and had been disabled for several months. Roentgenographic examination (Figs. 11 and 12) showed changes in both hips,—hypertrophic changes and thinning of the joint cartilage, more marked on the right than on the left. Postoperatively the patient never at any time complained of pain. He was allowed up on crutches in seventeen days and was discharged on the twenty-fifth day. At the time of discharge he got about very well indeed and was able to put on his right shoe for the first time in years. In five months he returned to his former occupation, which required jumping on and off trains. He was allowed to do this by promising that he would not jump on his right foot. When last seen, eight months after the operation, he had been back at work for three months; he complained of no pain and walked with a scarcely noticeable limp. Figures 13, 14, and 15 show this patient's function at this time. There was permanent flexion of 20

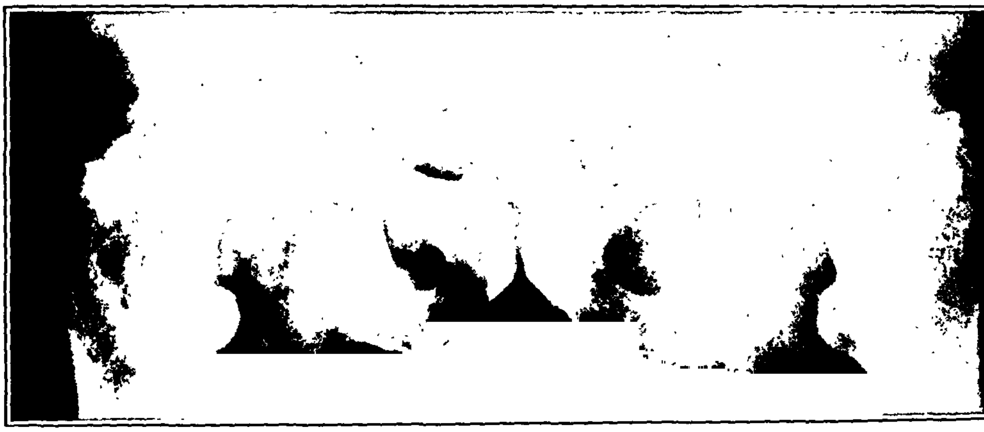

FIG. 16

Preoperative roentgenogram showing hypertrophic changes with thinning of the joint cartilage.

degrees, motion in flexion to a good 90 degrees, and very little abduction (it was estimated as 10 to 15 degrees).

This case is important because the patient had two more years to go before he could obtain a pension. If it is proved that this procedure does not give permanent relief, it may at least be useful in producing temporary relief and improved function over an important period of time.

The second case was a blacksmith, fifty-eight years old. He had been in constant pain for several months before admission to the hospital. According to his story, he was unable to lie. sit, stand, or walk without pain. Figure 16 shows the condition before operation. The same procedure was performed. (See Figure 17.) In the course of five months the patient returned to his blacksmith shop to do a couple of hours' work a day. At the end of nine months he worked all day when he could find the work to do. Even at the time when this report was written, ten months after the operation, he walked with a very distinct limp, but this limp was unaccompanied by pain. He was comfortable lying, sitting, standing, and walking. Function at the end of nine months was as follows: 30 degrees of permanent flexion, motion in flexion to a good 90 degrees, abduction of approximately 10 degrees (Figs. 18, 19, and 20).

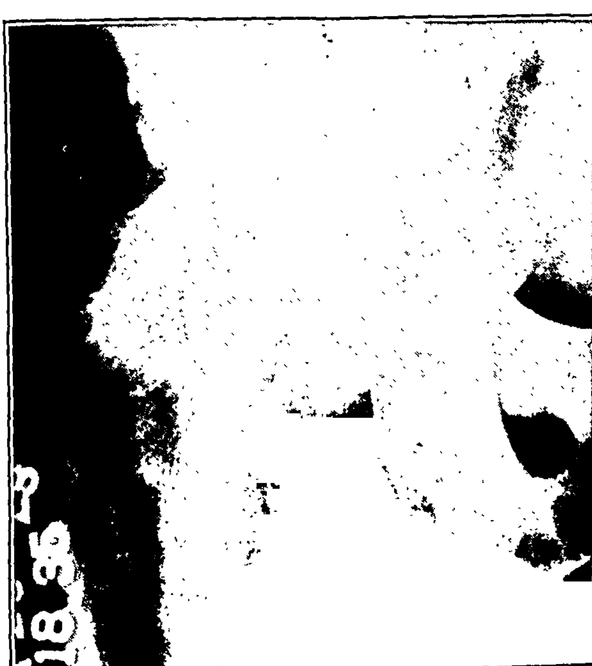

FIG. 17

Postoperative roentgenogram. Not much change is demonstrable.

Eleven cases have been treated by this method,—eight of "malum coxae senilis", two of "old slipped femoral epiphysis", and one of "intrapelvic protrusion of

the acetabulum''. They have all done well; the relief from pain is the outstanding feature; gain in motion is definite but not marked. Most of the patients still have a perfectly definite, noticeable limp.

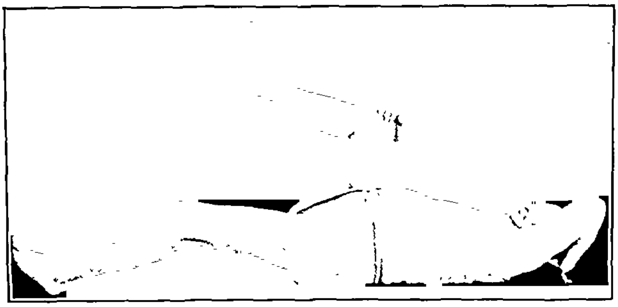

FIG. 18

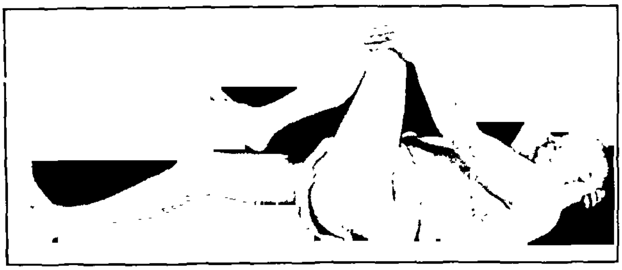

FIG. 19

POSTOPERATIVE TREATMENT

The outstanding feature of the postoperative period is the slight amount of pain complained of; some patients state that they have no "pain" at all, others say they have "soreness", but none complain of acute pain.

The affected extremity is suspended with five pounds of traction in the optimum position,—maximum abduction and internal rotation, minimum flexion.

Following two weeks of recumbency the patient is gradually allowed to sit up and is trained to use crutches. The period of hospitalization should be a minimum of three weeks, a maximum of four. When the patient leaves the hospital he should be thoroughly trained in exercises to maintain the corrected position.

FIG. 20

COMMENTS

In the cases so far operated upon, the author's attention has been directed chiefly to the anterior acetabular wall and to the anterior capsule of the hip joint. (See Figure 21.) In some cases a plastic procedure has been performed on the anterior femoral head and neck, when they have been the seat of advanced proliferative changes. The inferior portion of the head and neck has likewise been removed for the same reason; this has been done in two cases only. The posterior aspect of the head and neck has been left untouched. This may be one reason why a greater improvement

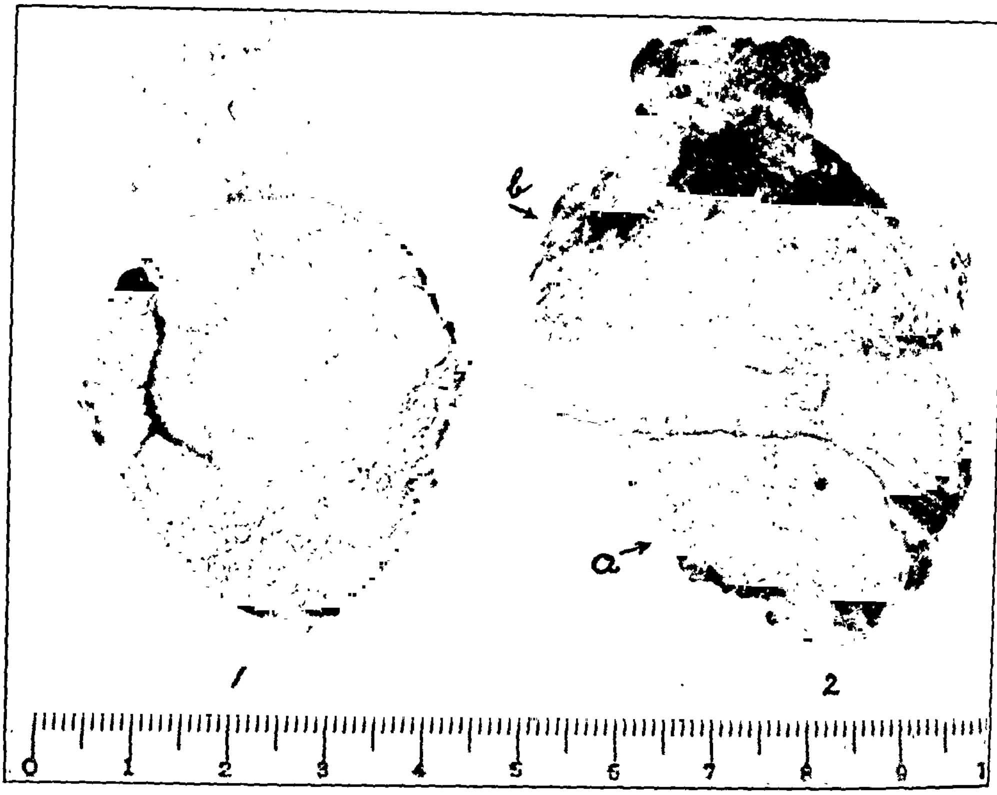

FIG. 21

Characteristic appearance of specimen removed, consisting of: *a*, acetabular wall; *b*, attached capsule. *1* shows the specimen as viewed from the outside; *2* shows the intra-articular synovial surface.

in range of motion has not been obtained. The writer considers it unwise to attack this region.

Gentle manipulation for the sake of increasing the range of motion has been carried out in some of the cases at the end of the operative procedure. It is the author's feeling that this is distinctly worth while and should be done routinely.

SUMMARY

A plastic procedure has been proposed for the relief of hip-joint conditions resulting from interference with the normal mechanics of the hip joint. Such conditions are "malum coxae senilis", "intrapelvic protrusion of the acetabulum", "old slipped upper femoral epiphysis", "fractures of the neck of the femur with malposition", "Legg-Calvé-Perthes disease", and "fractures of the acetabulum".

Sufficient time has not elapsed to obtain true end results, but the author feels justified in rendering this preliminary report because the method is non-destructive and seems effective in relieving pain in conditions for which there is no other adequate treatment.

ARTHROPLASTY OF THE KNEE JOINT

BY J. ED. SAMSON, M.D., MONTREAL, CANADA

During the last twenty-five years arthroplasty has frequently been practised by orthopaedic surgeons of all countries. Ollier of Lyon, Murphy of Chicago, Putti of Bologna, and MacAusland of Boston have been the pioneers in performing this operation.

Up to 1935 * the author performed thirty-seven arthroplasties for ankylosis of the knee joint. Of these thirty-seven patients, twenty-four were female and thirteen were male. Their ages ranged from eighteen to fifty-four years. These cases may be classified as follows:

Nature of Ankylosis	*No. of Cases*
Gonococcus	15
Trauma	3
Osteomyelitis	1
Tuberculosis	2
Staphylococcus septicaemia	5
Hypertrophic osteo-arthritis	7
Surgical infection of knee	3
Congenital deformity	1
Total	37

The author refuses to operate on patients under eighteen years of age on account of the risk of traumatizing the epiphyseal line. Experience has shown that the best results are obtained in patients ranging in age from twenty to forty years. The patients are always informed that the postoperative treatment will be painful and of long duration, and that their complete cooperation is necessary to obtain a good result.

Various writers claim that bony ankylosis usually gives better results than fibrous ankylosis, but the author has obtained about the same results from both types of ankylosis.

All acute symptoms should have ceased at least one year before the operation. The limb operated on should have good, strong muscles and be about the same length as the other one.

Some claim that arthroplasty gives an unstable, painful and motionless joint, but all experienced orthopaedic surgeons who have frequently performed that operation know that these accusations are false; on the contrary, the new joint allows fully 90 degrees of flexion and gives a very stable and supple knee. Some of the writer's patients were operated on ten years ago and they have been walking and working ever since, with the greatest ease and without any discomfort.

The author always uses a free flap of fascia lata as a transplant.

* During 1935 eleven more arthroplasties for ankylosis of the knee joint were performed by the author.

TABLE I

Analysis of Thirty-Seven Arthroplasties for Ankylosis of the Knee Joint

Case		Sex	Age (Years)	Nature of Ankylosis	Side	Duration
1.	M. H.	Female	20	Acute suppurative arthritis	Right	10 months
2.	L. B.	Male	39	Gonorrhoeal arthritis	Right	1 year
3.	C. L.	Female	20	Septicaemic arthritis	Right	5½ years
4.	D. F.	Female	24	Gonorrhoeal arthritis	Left	14 months
5.	L. O.	Female	17	Tuberculous arthritis	Left	5 years
6.	J. D.	Female	38	Gonorrhoeal arthritis	Left	2 years
7.	F. M.	Female	22	Gonorrhoeal arthritis	Right	1 year
8.	O. L.	Male	36	Tuberculous arthritis	Right	28 years
9.	C. V.	Female	43	Gonorrhoeal arthritis	Right	14 months
10.	W. B.	Female	54	Chronic arthritis	Bilateral	9 years
11.	J. D.	Male	24	Gonorrhoeal arthritis	Right	2 years
12.	E. T.	Female	31	Gonorrhoeal arthritis	Bilateral	18 months
13.	J. L.	Female	18	Acute osteomyelitis of the femur	Right	11 years
14.	E. B.	Female	22	Gonorrhoeal arthritis	Right	1 year
15.	A. D.	Male	54	Fracture of the tibia	Right	2 years
16.	A. B.	Male	19	Infected wound	Left	2 years
17.	L. G.	Female	25	Gonorrhoeal arthritis	Left	3 years
18.	J. E. P.	Female	38	Gonorrhoeal arthritis	Right	2 years
19.	A. F.	Male	35	Chronic osteo-arthritis	Right	2 years
20.	M. A. P.	Female	29	Gonorrhoeal arthritis	Right	2 years
21.	E. C.	Male	18	Traumatic arthritis	Left	13 months
22.	R. L.	Female	36	Gonorrhoeal arthritis	Left	18 months
23.	S. C.	Female	22	Osteomyelitis of the femur	Left	3 years
24.	D. G.	Female	27	Gonorrhoeal arthritis	Left	1 year
25.	L. L.	Female	26	Congenital deformity of the femur	Left	Congenital
26.	E. M.	Male	25	Undetermined	Right	2 years
27.	C. L.	Female	24	Gonorrhoeal arthritis	Right	2 years
28.	E. C.	Male	46	Chronic osteo-arthritis	Left	6 years
29.	F. G.	Female	22	Suppurative arthritis	Right	3 years
30.	S. M. E.	Female	52	Ankylosed chronic arthritis	Right	18 years
31.	E. R.	Male	44	Traumatic arthritis	Left	6 years
32.	E. L.	Female	48	Ankylosed chronic arthritis	Right	5 years
33.	P. L.	Female	21	Suppurative arthritis	Right	10 years
34.	M. M.	Male	19	Suppurative arthritis	Right	2 years
35.	H. D.	Male	34	Traumatic arthritis	Left	2 years
36.	Y. H.	Male	38	Gonorrhoeal arthritis	Right	14 months
37.	A. C.	Male	54	Chronic hypertrophic osteo-arthritis	Left	6 years

TABLE I (*Continued*)

Case		Date of Admission	Date of Arthroplasty	Mobilization under Anaesthesia	Duration of Physical Therapy
1.	M. H.	Nov. 5, 1925	Nov. 8, 1925	Jan. 10, 1926	1 year
2.	L. B.	Sept. 4, 1928	Sept. 8, 1928	Nov. 17, 1928	6 months
3.	C. L.	Oct. 15, 1928	Oct. 31, 1928	Jan. 7, 1929	6 months
4.	D. F.	Feb. 26, 1932	March 2, 1932	None	None
5.	L. O.	May 28, 1926	June 6, 1926	None	None
6.	J. D.	Nov. 5, 1926	Nov. 10, 1926	None	2 months
7.	F. M.	May 28, 1927	June 3, 1927	Nov. 4, 1927	None
8.	O. L.	Sept. 6, 1933	Sept. 13, 1933	Jan. 3, 1934	1 month
9.	C. V.	Jan. 27, 1930	Jan. 30, 1930	None	4 months
10.	W. B.	June 8, 1934	June 20, 1934 (left)	None	None
11.	J. D.	May 18, 1933	June 1, 1933	Sept. 13, 1933	None
12.	E. T.	June 9, 1932	June 14, 1932 (left)	Aug. 24, 1932	None
			Sept. 1, 1933 (right)	None	None
13.	J. L.	May 18, 1927	June 8, 1927	None	None
14.	E. B.	Jan. 10, 1934	Feb. 8, 1934	April 20, 1934	5 weeks
15.	A. D.	Jan. 3, 1933	Jan. 7, 1933	March 10, 1933	1 month
16.	A. B.	March 16, 1933	March 20, 1933	June 18, 1933	None
17.	L. G.	June 1, 1934	June 5, 1934	None	None
18.	J. E. P.	Aug. 3, 1934	Aug. 8, 1934	None	None
19.	A. F.	Nov. 26, 1933	Nov. 30, 1933	Feb. 16, 1934	None
20.	M. A. P.	Sept. 14, 1928	Sept. 20, 1928	None	None
21.	E. C.	July 19, 1927	July 28, 1927	Sept. 2, 1927 Oct. 3, 1927	2½ months
22.	R. L.	July 1, 1932	July 4, 1932	None	None
23.	S. C.	April 4, 1932	April 9, 1932	None	None
24.	D. G.	March 13, 1932	March 17, 1932	None	None
25.	L. L.	Oct. 4, 1933	Oct. 10, 1933	Jan. 12, 1934	None
26.	E. M.	Aug. 1, 1933	Aug. 5, 1933	None	None
27.	C. L.	Feb. 14, 1934	Feb. 17, 1934	April 20, 1934	None
28.	E. C.	June 18, 1928	June 22, 1928	July 15, 1928	None
29.	F. G.	June 25, 1928	June 30, 1928	Aug. 20, 1928	None
30.	S. M. E.	April 20, 1930	April 26, 1930	June 15, 1930	None
31.	E. R.	March 4, 1931	March 7, 1931	May 8, 1931	None
32.	E. L.	June 3, 1933	June 8, 1933	July 30, 1933	None
33.	P. L.	Feb. 1, 1928	Feb. 4, 1928	March 6, 1928	1½ months
34.	M. M.	Sept. 1, 1934	Sept. 5, 1934	Nov. 5, 1934	None
35.	H. D.	Nov. 20, 1934	Nov. 29, 1934	Jan. 20, 1935	None
36.	Y. H.	Oct. 19, 1934	Oct. 23, 1934	Jan. 10, 1935	1 year
37.	A. C.	Aug. 2, 1927	Aug. 5, 1927	None	6 months

TABLE I (*Continued*)

Case		Condition on Discharge: Degree of Flexion	Degree of Extension	Stability of the Joint	Final Result and Postoperative Period
1.	M. H.	150 degrees	Complete	Good	Good, 1 year
2.	L. B.	60 degrees	Complete	Good	Good, 6 months
3.	C. L.	90 degrees	Complete	Good	Good, 6 months
4.	D. F.	80 degrees	Complete	Good	Good, 3 months
5.	L. O.	60 degrees	Complete	Poor	Poor, 1 year
6.	J. D.	60 degrees	Complete	Good	Good, 4 months
7.	F. M.	90 degrees	Complete	Good	Good, 4 months
8.	O. L.	90 degrees	Complete	Good	Good, 5 months
9.	C. V.	90 degrees	Complete	Good	Good, 6 months
10.	W. B.	60 degrees	Complete	Good	Good, 7 months
11.	J. D.	90 degrees	Complete	Good	Good, 1 year
12.	E. T.	90 degrees	Complete	Good	Good, 5 months
		None	Complete	Good	Ankylosis in extension, 3 months
13.	J. L.	None	Complete	Good	Ankylosis in extension, 4 months
14.	E. B.	70 degrees	Complete	Good	Good, 8 months
15.	A. D.	90 degrees	Complete	Good	Good, 5 months
16.	A. B.	80 degrees	Complete	Good	Good, 4 months
17.	L. G.	70 degrees	Complete	Good	Good, 5 months
18.	J. E. P.	70 degrees	Complete	Good	Good, 3 months
19.	A. F.	60 degrees	Complete	Good	Good, 6 months
20.	M. A. P.	40 degrees	Complete	Good	Good, 5 months
21.	E. C.	80 degrees	Complete	Good	Good, 6 months
22.	R. L.	20 degrees	Complete	Good	Good, 3 months
23.	S. C.	None	Complete	Good	Ankylosis in complete extension, 1 year
24.	D. G.	90 degrees	Complete	Good	Very good, 4 months
25.	L. L.	70 degrees	Complete	Good	Very good, 6 months
26.	E. M.	90 degrees	Complete	Good	Very good, 6 months
27.	C. L.	15 degrees	Complete	Good	Satisfactory, 6 months
28.	E. C.	40 degrees	Complete	Good	Good, 4 months
29.	F. G.	35 degrees	Complete	Good	Good, 6 months
30.	S. M. E.	70 degrees	Complete	Good	Good, 5 months
31.	E. R.	80 degrees	Complete	Good	Good, 4 months
32.	E. L.	60 degrees	Complete	Good	Good, 4 months
33.	P. L.	45 degrees	Complete	Good	Good, 7 months
34.	M. M.	15 degrees	Complete	Good	Satisfactory, 6 months
35.	H. D.	40 degrees	Complete	Good	Good, 3 months
36.	Y. H.	60 degrees	Complete	Good	Good, 1 year
37.	A. C.	70 degrees	Complete	Good	Good, 6 months

FIG. 1
Case 1. Before operation. Complete fusion of the femur with the tibia.

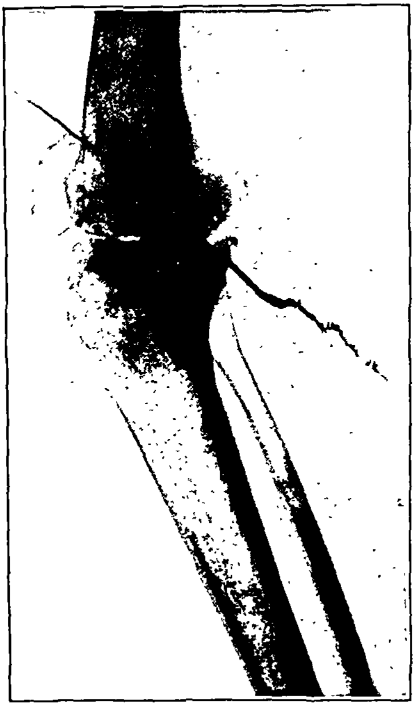

FIG. 2
Case 1. Four years after operation. Good space between the femur and the tibia. New articular cartilage may be seen on the tibia.

This membrane disappears after a while, to be replaced by a flattened fibrous tissue which contains true cartilage. The writer had occasion to reopen two knees upon which he had previously performed arthroplasties, and it was possible to verify the disappearance of the flap and the presence of a new chondroid covering of the articular surfaces.

In the first case, operated upon five years before, the articular space was about normal and the articular surfaces were hard, regular, and smooth. The capsule and lateral ligaments were tight and prevented lateral mobility. Crucial ligaments or fibrous bands which could replace them were not found. Some authors have attributed the great stability of the new joint to the production of fibrous bands which may replace the crucial ligaments. In this case the crucial ligaments were absent; the knee, however, was very stable in extension and in flexion. Before her last accident (fracture of the internal tibial condyle, after a fall), the patient could put all her weight on this limb, flexed to its limit, without any help whatever and she could raise herself easily.

In the second case, seven months after operation, a dense and abundant fibrous tissue covered the new tibial tendon and prevented its articulation with the condylar notch. The femoral and tibial articular surfaces were clothed with this fibrous and flattened tissue which allowed a good

deal of flexion. The excision of this exuberant scar tissue over the tibial tendon allowed complete extension.

Ankylosis of one knee in slight flexion or full extension is compatible with an ordinary normal life. Many people will accept it without any recrimination, while others will never resign themselves to having a stiff knee and will be ready to do anything to get back mobility in the joint. Ankylosis should always be respected when it is caused by a tuberculous or by an osteomyelitic infection. However, fusion of both knees or of both hips, or of one knee and of one hip, urges the surgeon to restore mobility to at least one of these joints to allow the patient the advantage of sitting and walking alone.

In a word, arthroplasty is questionable in a case of ankylosis of one knee; it is always recommended when more than one joint of the lower extremity is fused.

OPERATIVE TECHNIQUE

Various techniques, with more or less important modifications, have

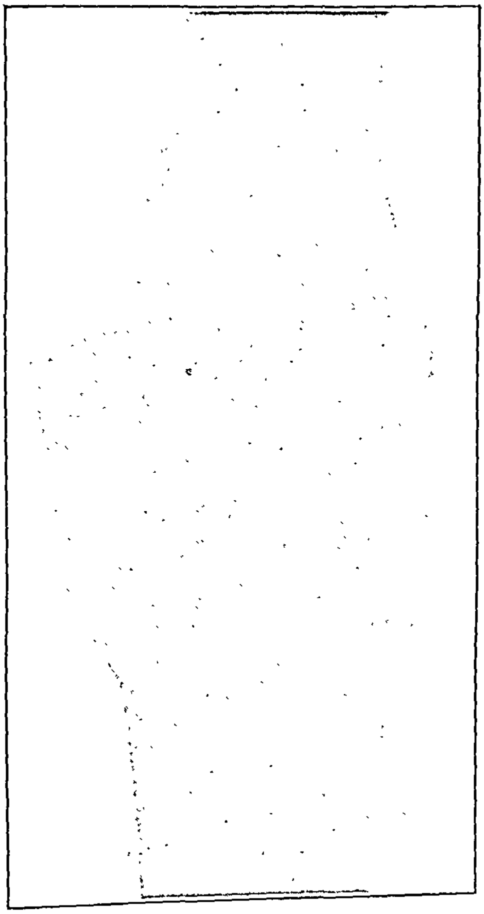

Fig. 3

Case 2. Before operation. Destruction of the internal tibiofemoral articular surfaces. Fibrous tibiofemoral ankylosis.

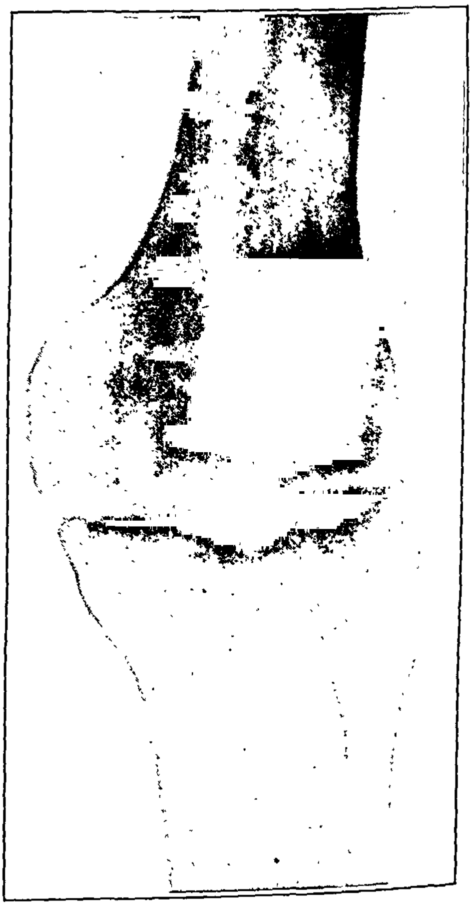

Fig. 4

Case 2. Eight months after operation. The articular space is wide, and the tibial tendon is visible in the enlarged intercondylar opening.

Fig. 5
Case 3. Before operation. Bony tibiofemoral ankylosis.

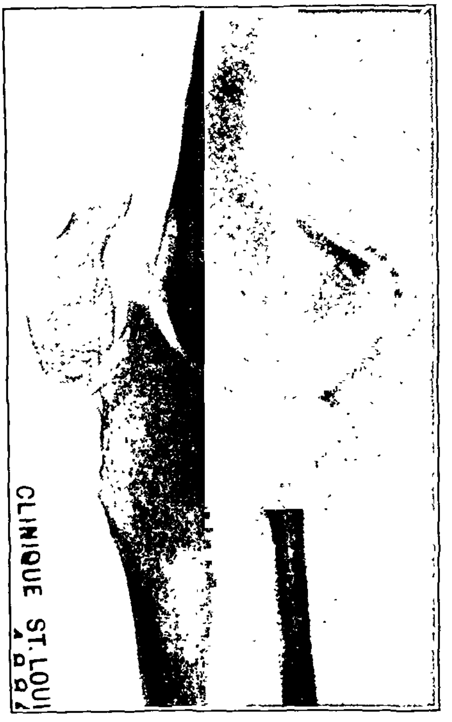

Fig. 6
Case 3. Seven years after operation. The articular space is good. The patella is lengthened and is separated from the femur and from the tibia by a good space. The articular cartilage is dense and very regular.

been employed by surgeons. The following method has been employed in all of the author's cases.

The incision on the internal aspect of the knee is used and the usual Putti technique is employed, with the exception that the writer always constructs in the center of the tibia a tendon which, when once introduced in the intercondylar groove especially built for this purpose, prevents lateral displacement of the femur on the tibia. The tourniquet is removed only when the cast is dry and fits the knee well. For the last four years traction on the limb after the operation has been omitted. The cast is left in place about ten days; then, if the wounds are healed, massage and passive mobilization are employed every day for ten minutes. Active mobilization is permitted about the twentieth day after the operation; walking on the limb with the help of crutches is allowed at the end of one month. The patient is encouraged to put some weight on the limb and to use the quadriceps as much as he can to get active motion in the knee and also to make the new surfaces rub against each other.

With the exception of gentle massage, mobilization, and mecanotherapy, which are of great help to the patient, the writer has given up physiotherapy almost entirely. In ten of the arthroplastic cases only massage and mobilization were employed, while in the others diathermy,

Examination, on January 9, 1926, showed complete extension and passive flexion of 50 degrees. Later, mobilization, under anaesthesia, resulted in flexion of 90 degrees. The knee was then immobilized in extension for two days, after which passive motion and massage were begun and continued daily.

The patient walked with two crutches until April 10, 1926. At this time there was flexion of 60 degrees and complete extension. The patient left the hospital using only one cane.

On October 29, 1927, examination showed complete extension and flexion of 110 degrees. The knee was stable and the gait was normal. Figure 2 shows the regularity of the contours of the new joint.

The patient has led a normal life since 1927 and has studied to be a nurse. When she was last seen in July 1933, examination revealed practically normal flexion, complete extension, no lateral mobility, and painless movements.

Case 2. L. B., a male, thirty-nine years old, was seen on May 16, 1928. The patient gave a history of ankylosis of the right knee, after vaccine and cast treatment, following a gonorrhoeal arthritis in June 1927.

Physical examination showed a healthy adult, five feet, five inches in height, weighing 140 pounds. The right knee was ankylosed in full extension (Fig. 3) and showed no evidence of activity.

On September 8, 1928, an arthroplasty was performed. A cast, combined with traction, was left in place for ten days. After the removal of the cast, traction was continued for twelve days. Passive movements were made up to November 17, 1928.

Examination, on November 17, 1928, showed complete extension and a range of 30 degrees of passive flexion.

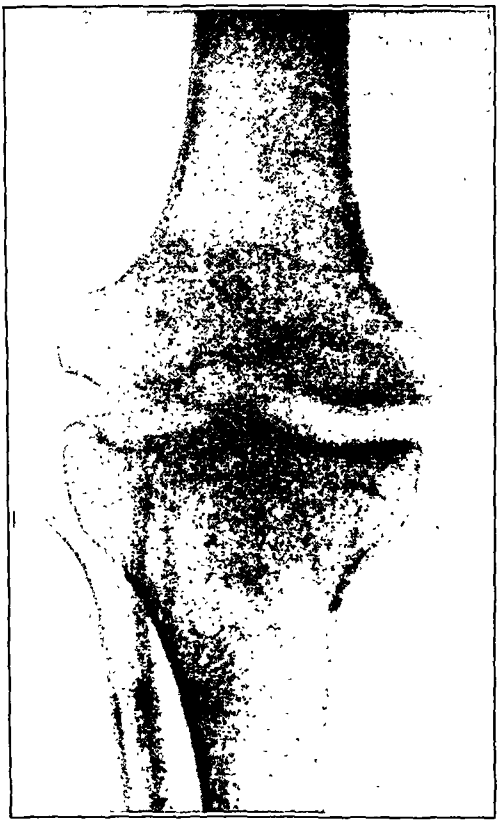

Fig. 8

Case 8. Fifteen months after operation. The articular space is good. The tibia and the femur are in good alignment.

On November 17, 1928, mobilization, under anaesthesia resulted in flexion of 90 degrees, followed by physiotherapy, diathermy, galvanic current, and massage for a period of six months.

Examination, on May 5, 1929, showed complete extension and flexion of 60 degrees. The movements were free from spasm and pain. Figure 4 shows the shape of the new joint.

The patient has not been examined since that date, but it is known that he is walking well.

With the exception of three cases, arthroplasty of the knee gave a good functional result in each case.

FIG 12
Case 14. Before operation. Lessening of the articular space of the knee and ossification of the crucial ligaments.

FIG. 13
Case 14. Four months after operation. Good articular space and satisfactory tibiofemoral contact. The tibial tendon is in good contact with the intercondylar opening.

LOCALIZED HYPERTROPHIC CHANGES IN THE CERVICAL SPINE WITH COMPRESSION OF THE SPINAL CORD OR OF ITS ROOTS *

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The commonest pathological finding observed in the roentgenographic examination of the spine in people over middle life is the so called "hypertrophic arthritis" of the vertebral bodies. It is a striking fact, however, that, while these familiar hypertrophic changes are seen very commonly on the anterior and lateral aspects of the body, it is rare to find them on its posterior aspect. The reason for this is not entirely clear, but, according to Beadle, the fibers of the posterior longitudinal ligaments have a very sparse attachment to the bone and are joined to the posterior ends of the intervertebral discs, while the anterior longitudinal ligament is attached more directly to the bone, which apparently leads to the formation of osteophytes on the anterior aspect of the vertebral body.

Some writers[9] on vertebral diseases comment on the absence of osteophytes coming from the posterior aspect of the bodies, but there are a few reports scattered throughout the literature of cases in which symptoms have apparently resulted from such a condition.[1, 3, 4, 6, 7, 8]

Schmorl has described little herniations of the nucleus pulposus which now go by the name of "Schmorl's nodes". These usually push into the substance of the bodies of the vertebrae through their upper or lower surfaces, but they may project posteriorly into the spinal canal. There are cases described in which symptoms have been caused by pressure on the cord from these nodes. Posterior projecting hypertrophic spurs must be distinguished from Schmorl's nodes in this position. These nodes are not visible in the roentgenograms unless they are calcified, while, of course, the hypertrophic bone changes are easily seen.

It has been pointed out by Hubeny that hypertrophic changes about the lateral aspects of the vertebral bodies may so diminish in size the canals for the spinal nerves that symptoms of "radiculitis" develop. The author believes that this takes place more commonly than is generally believed.

Owing to the anatomical arrangement of the cervical spine, hypertrophic changes in this area are more liable to encroach on a nerve canal than in the dorsal or lumbar areas. The usual anteroposterior and lateral roentgenograms of the spine fail to show the nerve canals and should be supplemented by oblique views if the examination is to be complete. One can be suspicious of involvement in the region of the nerve canals if

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 18, 1936.

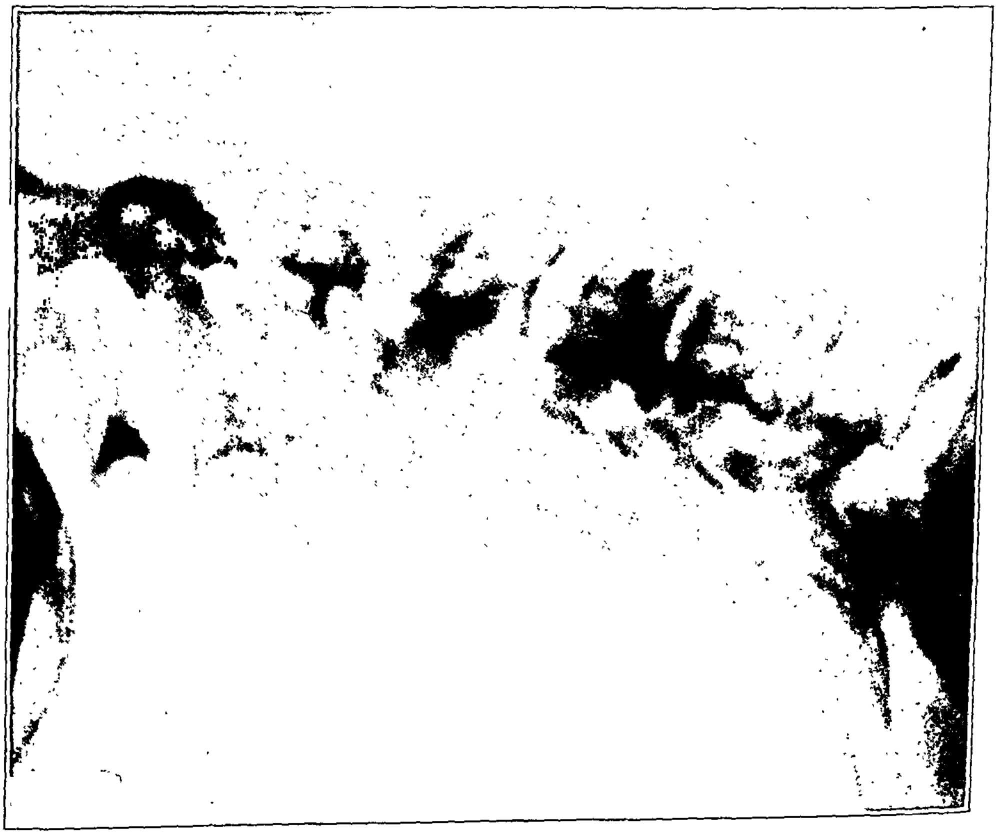

Fig. 1

Lateral view of the cervical spine, showing osteophytes projecting into the cervical canal opposite the interspace between the fifth and sixth cervical vertebrae.

Fig. 2

Anteroposterior view of cervical spine, showing on the right side a hypertrophic thickening of the lateral portion of the upper surface of the sixth cervical vertebra.

Fig. 3

Right oblique view, showing a marked projection into the nerve canal for the sixth cervical nerve.

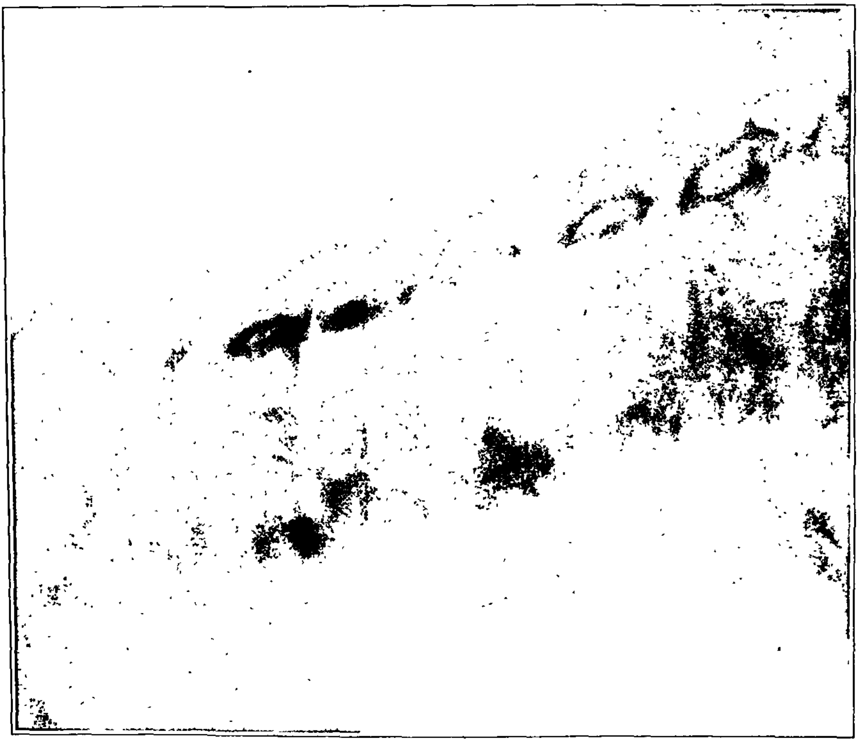

Fig. 4

An oblique roentgenogram of the same case as seen in Figs. 1, 2, and 3, showing normal nerve canals on the other side.

one sees in the anteroposterior roentgenogram a hypertrophic thickening of the concave lateral portion of the upper surface of the vertebral body. When this is seen, oblique roentgenograms should be taken.

In two of the cases which follow, arthritic changes were demonstrated in the roentgenograms about the nerve canals, as well as on the posterior aspects of the vertebral bodies; in the third case, the latter finding alone was present.

CASE REPORTS

CASE 1. A man, aged fifty-seven, a professional athlete, was admitted to the hospital for study. His presenting symptom was numbness and tingling in the extremities. He had uncertainty in walking and girdle sensations about the abdomen. The symptoms were more pronounced on hyperextension of the cervical spine. The knee jerks were very active and the vibratory sense was lost at the ankles. There was a positive Babinski reflex on the right and considerable awkwardness in the use of the fingers in carrying out finer movements.

Spinal puncture showed evidence of a subarachnoid block, but when the head was extended to where numbness was felt in the fingers there was evidence of complete block.

Roentgenograms of the cervical spine showed a "very marked hypertrophic arthritis with the projection of a hypertrophic process posteriorly into the vertebral canal opposite the discs between the fourth and fifth cervical vertebrae". In addition to this, there were some hypertrophic changes on the lateral aspects of the bodies leading to diminution in the size of the nerve canals. There was some atrophy of the neck and shoulder muscles on the right side. Laminectomy was performed. A very definite projection, looking very much like a date pit laid transversely, was found extending across the anterior part of the spinal canal at the level previously mentioned. This was not removed. There has been considerable improvement since the operation, which was two years ago.

CASE 2. A woman, aged sixty, a housewife, was sent for a roentgenographic examination to rule out a cervical rib. She complained of pain and abnormal sensations in both arms, particularly in the right, and about the back of the neck. In the right hand the pain was limited to the radial and median nerve areas. Roentgenographic examination revealed a very definite marked projection of hypertrophic processes posteriorly into the spinal canal. This was present only opposite the interspace between the fifth and sixth cervical vertebrae. The rest of the spine was relatively free from arthritic changes except that there were considerable hypertrophic changes about the lateral portions of the fifth and sixth vertebral bodies on the right side, which encroached on the nerve canal for the sixth cervical nerve on the right side.

CASE 3. A woman, aged fifty-five, a housewife who always did very heavy work, came complaining of pain in the right arm and hand. The cervical spine was examined roentgenographically as a matter of routine and posterior projecting hypertrophic processes were found opposite the space between the fourth and fifth and the sixth and seventh cervical bodies. There were no arthritic changes about the other joints of these vertebrae and no encroachment of the nerve canal. No definite neurological signs were demonstrable. The patient experienced little if any relief from wearing a collar.

COMMENT

The purpose of this communication is to emphasize the occurrence of localized areas of hypertrophic change in the cervical spine, which may occur in such a position as to exert pressure on important nerves.

There seems no doubt that these hypertrophic processes can extend into the spinal canal and can press on the cord.

To show these changes most satisfactorily, lateral roentgenograms should be taken in the upright position at a six-foot distance. If the symptoms or the anteroposterior roentgenograms suggest involvement of the cervical nerves as they pass through the nerve canals, oblique roentgenograms should be taken. In interpreting oblique roentgenograms of the cervical spine, it should be remembered that the size of these cervical-nerve canals is not constant,—they are larger above and diminish in size as they descend. The smallest ones are those for the sixth and seventh cervical nerves.

These cases are evidently not common, but they do occur, and, in cases of obscure pain in the neck or in the arm, the possibility of pressure on the cord or nerves by osteophytes has to be kept in mind. The author has seen two patients who were sent to him with a provisional diagnosis of a cervical rib and who showed definite impairment in the size of the nerve canals, and two others who had posterior projecting osteophytes.

All the cases that the writer has seen have been in the cervical spine, although in the cases described in the literature these phenomena were found both in the dorsal and in the lumbar spines, as well as in the cervical spine.

SUMMARY

Hypertrophic changes are frequently seen on the anterior and lateral aspects of the vertebral bodies, but their presence on the posterior aspect, where they would encroach on the spinal canal, is very uncommon. They do, however, occur in this location and the author has reported cases with posterior projecting hypertrophic processes which apparently caused symptoms.

Hypertrophic changes occurring on the lateral aspects of the bodies of the vertebrae in the cervical spine may encroach on the canals for the cervical nerves and cause symptoms.

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OSTEITIS CONDENSANS ILII

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When examining roentgenograms of the pelvis, one occasionally notes in the ilium a localized area of increased density, involving usually the inferior and medial portion adjacent to the sacro-iliac joint.

In 1926 Sicard, Gally, and Haguenau in France discussed the condition and contributed five case reports. They spoke of osteitis condensans as having occurred elsewhere in the skeleton and described a case which involved the os calcis and also the fourth and fifth lumbar vertebrae. They took pains to exclude the possibility of an osteoplastic type of metastasis in the vertebral lesion.

Bársony and Polgár called attention to this condition in 1928, referring to it as "osteitis condensans ilii". Bársony described the lesion as a "sclerosing bone disease, easily demonstrable by x-ray and confined to the os ilii". These authors described fifteen cases which came to their attention in a period of one and one-half years.

The next mention of the subject was at a gynecological congress in Göttingen in 1932 when Fritz Berent correlated the condition to the trauma incident to childbirth.

During the past few years at the Kings County Hospital the authors have observed twelve patients who exhibited this condition. Complete roentgenographic and laboratory studies of these patients have been made and the findings form the basis of this paper.

Characteristically in this condition there occurs a zone of markedly dense bone in that portion of the ilium adjacent to the sacro-iliac synchondrosis; usually the involvement starts near the most inferior portion of the joint. It may be limited to a very small area, several millimeters in diameter, or it may involve the entire extent of the ilium as it adjoins the sacrum. The area may be sharply demarcated from the surrounding normal bone or it may gradually merge with it.

On the usual negative it appears as if that portion of the roentgenogram had been underexposed, as pointed out by Bársony; no trabeculae nor bony structures are visible in the involved area. On a purposely overexposed film, however, the bony trabeculae may be seen to be thickened and irregular. The lacunar spaces appear as if filled with a greater calcium deposit than usual, and the entire involved zone has a uniformly opaque appearance.

The sclerosis ends very abruptly at the sacro-iliac joint. The outer border of the lesion fades somewhat more gradually into the normal

iliac bone. The sacro-iliac joint proper never shows any evidence of involvement. The joint space is clear, is of normal width, and presents no irregularities of the articular surfaces either on the iliac or on the sacral side.

FIG. 1-A

Osteitis condensans ilii of the left side.

FIG. 1-B

Osteitis condensans ilii of the right side. Note the sharp demarcation of the sclerosed zone and the lack of involvement of the sacro-iliac joint.

The ordinary manifestations of any osteo-arthritis are absent.

Although the involvement appears to have its origin near the inferior portion of the joint, it may extend upward to involve a considerable portion of the iliac bone, even reaching to the crest. The entire iliac surface of the sacro-iliac joint may become sclerosed.

Due to the oblique direction of the joint, and because of the superimposition of the auricular surfaces of the ilium and sacrum, it often appears as if the sclerosis extends through the joint, involving the sacral side. Indeed, in cases where the sclerosis is particularly pronounced, it may be difficult to distinguish the articular space, the ilium and sacrum appearing almost as if fused. Roentgenograms taken in the oblique position to demonstrate the joint space readily prove that the process stops sharply at the iliac surface and does not involve the joint.

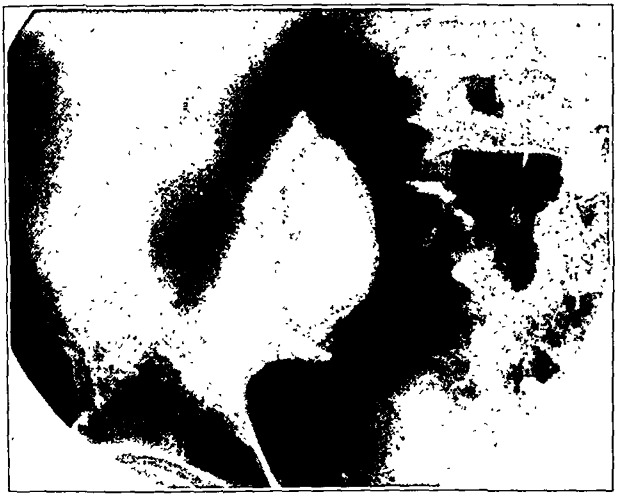

FIG. 2-A

Purposely overpenetrated film to show thickening of the bony trabeculae and filling in of the intertrabecular spaces. Note that, due to the superimposition of the iliac and sacral surfaces in the anteroposterior view, the process appears to extend across the joint space to involve the sacrum.

FIG. 2-B

Same case as Fig. 2-A. Oblique view showing that the process involves only the ilium and stops sharply at the sacro-iliac joint. The sacral surface is not involved.

Bársony states that the sacrum is never involved, but in one case of the authors' series a similar small zone of condensation was found on the sacral as well as on the iliac borders. Significantly enough, in this case the intervening joint shows no involvement.

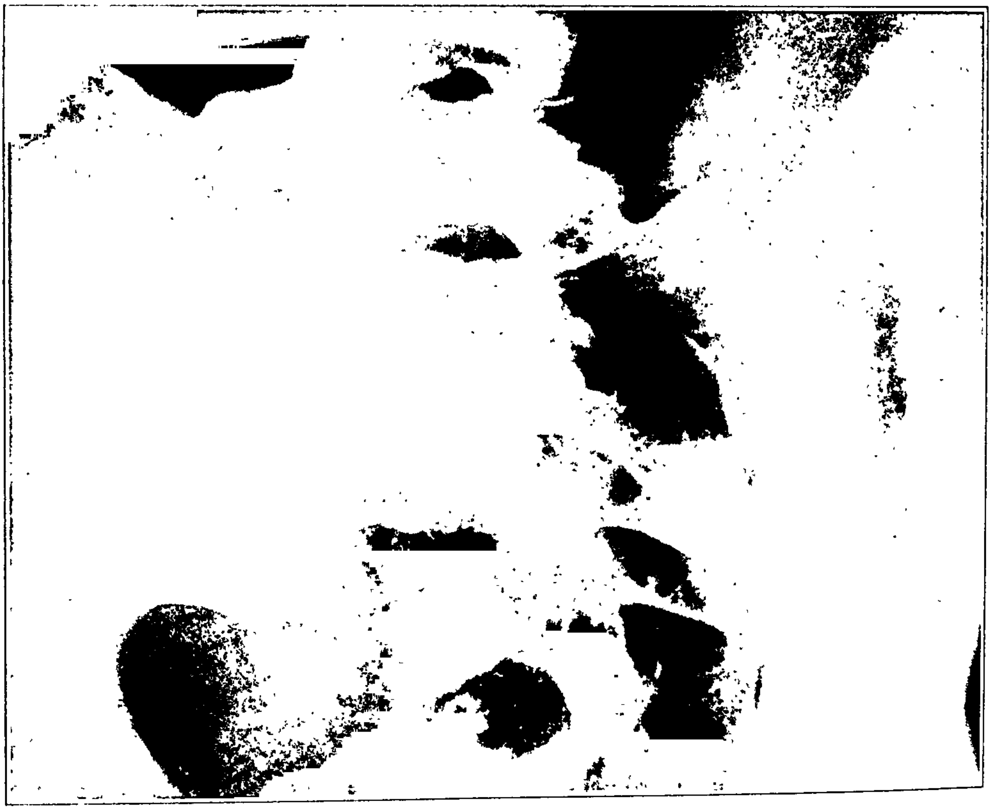

FIG. 3-A

FIG. 3-B

Bilateral osteitis condensans ilii. Oblique views illustrating the sharp limitation of the process to the iliac bone and the lack of encroachment on the sacro-iliac joint.

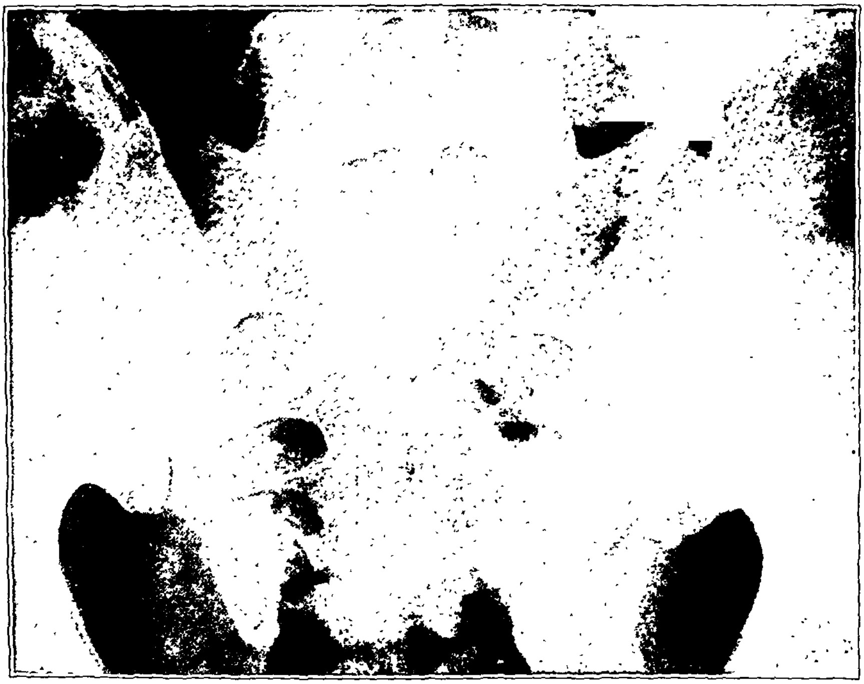

FIG. 4-A
Case F. H. Bilateral osteitis condensans ilii. Before operation.

FIG. 4-B
Same case. At operation a fairly large oblong section of bone was removed from that part of the ilium adjacent to the upper half of the sacro-iliac joint.

Fig. 5

Early case showing a very small area of condensation.

The condition has been described by others as being unilateral, although in four of the cases of the group here reported definite and equal bilateral involvement was observed.

Were it not for the fact that some of these cases present clinical complaints referable to this area, osteitis condensans would properly be relegated to the class of roentgenographic curiosities, interesting but of no known clinical significance.

However, some of these patients have definite complaints referable to the sacro-iliac region. In cases where symptoms occur, the complaint is usually that of low-back pain, often over the sacro-iliac region, either unilateral or bilateral, and frequently radiating down the posterior surface of the corresponding thigh and leg. The pain may be aggravated by bending; several patients complained of inability to lace their shoes. Relief may be obtained on assuming the recumbent position. Occasionally a limp may occur on the affected side. The degree of pain has not been proportionate to the extent of involvement. Whether these complaints can be entirely ascribed to osteitis condensans is, in the opinion of the authors, questionable. It must be stressed that in this series cases have occurred with very definite sclerosis, but without symptoms referable to this area. These cases are discovered incidentally to examinations of systems other than the skeletal. Such findings as a localized osteosclerosis should not be seized upon as the reason for any type of lumbosacral or sacro-iliac symptoms which the patient may present.

Physical findings in cases of osteitis condensans are usually scant and not very informative. Tenderness on palpation over the involved region and slight muscular spasm may be noted. The deep reflexes are normal.

Little is known in regard to the etiology. Fritz Berent in an earlier article definitely stated that osteitis condensans occurs only in females, usually in multiparae, and concluded that "Osteitis condensans is the result and late finding of periosteal, ligamentous, and capsular trauma due to gravidity and labor." He infers that this condition is limited to one

sex. This inference has been disproved by the series here reported, in which definite cases have been observed in the male. In the present series there were nine female and three male patients.

Bone syphilis has been excluded in these cases by serological studies, by the history, and by the noncharacteristic type of bone involvement. Likewise, Paget's disease, sclerosing osteomyelitis, osteo-arthritis, tuberculosis, lymphogranulomatosis, Hodgkin's disease, marble-bone, and osteoplastic types of metastases have been given consideration and have been excluded to our satisfaction in all of the present cases.

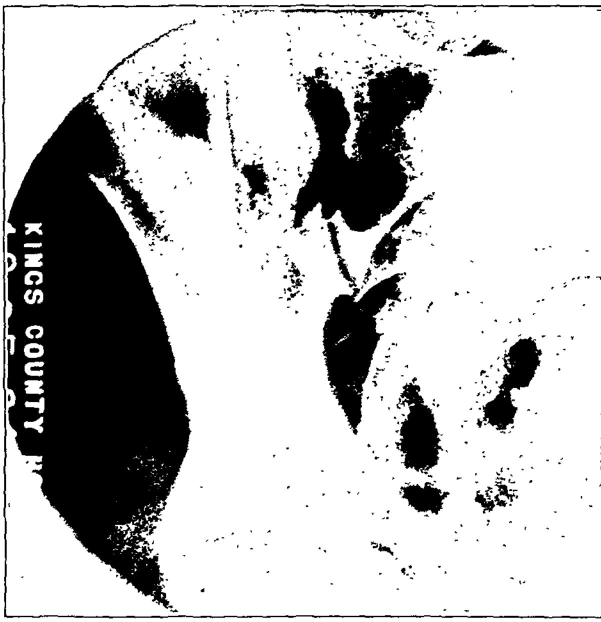

Fig. 6

Early case showing process limited to a small triangular area adjacent to the most inferior part of the sacro-iliac joint. The sacral surface appears to show similar involvement in this case.

A very thorough examination of the entire osseous system in each of the cases failed to show evidence of multiplicity of involvement. Likewise, the blood calcium and phosphorus determinations which were made in eight of the twelve cases were all normal and the phosphatase in the case in which an operation was performed was 7.2 units per 100 cubic centimeters of blood. A generalized disturbance of the calcium-phosphorus balance appears to be definitely excluded. Osteitis fibrosa and its variants merit no further consideration. Blood and urine studies likewise failed to uncover anything of significance.

As mentioned, Sicard, Gally, and Haguenau describe osteitis condensans as occurring also in the os calcis and in the fourth and fifth lumbar vertebrae. It seems probable that bones other than the sacrum may be involved by a similar process. We have observed one case that shows a striking and fairly extensive sclerosis of the coracoid and acromion processes as well as the axillary border of the scapula. This has not been included with those of the osteitis condensans series, but it does belong to the group of idiopathic localized osteoscleroses rather than to any other known entity.

Radiologists have frequently found small condensed and sclerosed islands of bone in various parts of the osseous system, particularly about

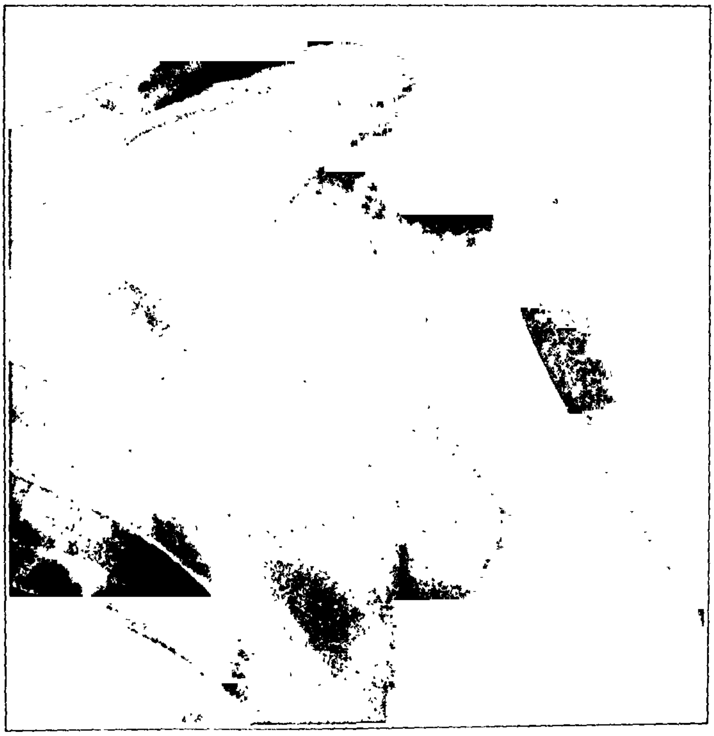

FIG. 7

Zones of condensation and sclerosis in the coracoid process, the acromion process, and the neck of the scapula. The relationship of these structures to osteitis condensans ilii is unknown.

the shoulder and the pelvis. While small compact bony islets are often referred to in the literature and in most texts, their significance is still lacking. Osteopoikilosis appears to be a more striking manifestation on a more widely distributed scale.

The question as to whether osteitis condensans ilii bears any relation to the above is necessarily for the future to determine, but, in the light of our present knowledge, no definite relationship suggests itself. The constancy of location and the extent and degree of sclerosis would seem to separate osteitis condensans ilii from the previously described small areas of condensed bone found occasionally in other parts of the skeleton.

Trauma as an etiological factor seems to deserve little consideration. While several of the patients of this series gave equivocal histories of having fallen or of having sustained some mild trauma at varying intervals prior to the onset of their symptoms, others in whom the sclerosis was most pronounced failed to give any history of antecedent injury. The etiological significance, therefore, remains questionable.

In a discussion of "ivory vertebrae", Bársony and Schulhof suggest that the sclerosis of ivory vertebrae may represent a reaction to a bacterial embolism with bacteria of low virulence. A local chronic infection might thereby be set up, and eburnation might result just as it does in Garrè's sclerosing osteomyelitis.

In the opinion of the authors, this possibility merits consideration in the etiology of osteitis condensans ilii. The variation in the extent of involvement in different cases—from an area of several millimeters to almost the entire sacral surface of the ilium—suggests a process of great chronicity, probably on a low-grade inflammatory basis. Cases have been followed and examined after one and one-half years without showing any appreciable change or progress in the roentgenograms.

A consideration of the blood supply of the ilium brings out a point of

interest and possibly of significance. A nutrient foramen occurs with great regularity in that part of the ilium adjacent to the inferior portion of the sacro-iliac joint. This is the part of the ilium that is the seat of osteitis condensans. That a relationship may exist between the local blood supply and the condensing osteitis is an interesting point to consider. It occasionally happens that instead of one foramen there are two or three nutrient foramina which are situated in this location, but which extend higher toward the crest. This may have a bearing on those cases of osteitis condensans in which the process is more extensive, involving almost the entire sacral surface of the ilium.

It is apparent that in this condition, as in so many others, the knowledge of the cause must wait upon thorough knowledge of the effect. Until we become thoroughly conversant with the histopathology, the etiology will in all likelihood remain obscure.

In one case of the present series, a section of sclerosed bone was removed during an operation to stabilize the joint. A review of the literature reveals no case in which there are operative or histological findings. It seems worthwhile, therefore, in view of the pathological data available, to present this case in somewhat greater detail.

F. H., male, aged thirty-six, married and the father of two children who were both well, five years previous to admission had begun to experience pain in the right sacro-iliac region. After bending, he would experience pain and difficulty in straightening up. The pain had been severe enough to incapacitate him for a week at a time. He had had short intervals that were symptom-free. There had been no sciatic radiation, the pain having been localized to the region over the sacro-iliac synchondrosis. There had been no past major illnesses. The occupation, that of salesman, could not possibly have played any etiological rôle.

In his youth, the patient had been very active and had participated in all the major sports. Six months after the original onset, he had fallen and landed on his right hip. This time he had been incapacitated for three weeks with the same type of pain in the right sacro-iliac region. A right-sided limp had followed this and the pain was present only at intervals, although there was always a sensation of residual soreness over the right sacro-iliac joint. The pain was always aggravated by bending. The patient managed to get along till January 2, 1935, when he had to be brought home from work and remained in bed for one month. While he was lying flat in bed the pain almost disappeared, except on twisting or turning. He entered the hospital on February 4 and again on March 21, 1935, with the diagnosis of sacro-iliac arthritis. The roentgenographic diagnosis was bilateral osteitis condensans ilii.

During the second admission, the patient was operated upon by the orthopaedic surgeon. The preoperative diagnosis was sacro-iliac arthritis, and a right sacro-iliac fusion was done. At operation, it was noted by the surgeon that the iliac bone adjacent to the right sacro-iliac joint was very sclerotic. The physical findings prior to operation were scant, there being present only a slight rigidity of the lumbar muscles. The laboratory findings were all essentially negative. The blood calcium was 11.1 milligrams per 100 cubic centimeters. The blood phosphorus was 3.9 milligrams per 100 cubic centimeters. The phosphatase was 7.2 units per 100 cubic centimeters of blood.

A section of bone was removed from the involved portion of the sacral surface of the ilium at operation for pathological study. The report of Dr. William Hala follows:

"There is a marked condensation of the osseous tissue with obliteration of the evident former lacunae. There appear to be no osteolytic or osteoclastic changes in the

bone and neither is there any evidence of overactivity of the osteoclasts or osteoblasts. In fact, these cells are more or less conspicuous by their absence. The marrow spaces contain an unusual number of myocytic and plasma types of cells. The significance of the plasma cells is undetermined. In general, the lesion appears to be of an osteitis condensans type. It is apparently independent of any inflammatory or other etiology, so far as can be ascertained from the histology of the specimen. Occasionally, in the condensed bone there appear to be depositions of lime salts which occur more or less in irregular linear areas, but more or less parallel to the lamellae of the bone. Diagnosis: osteitis condensans."

The patient was discharged after four weeks. He was still in a plaster jacket, but had obtained very marked relief.

Judging from the foregoing pathological report, it would appear that an inflammatory basis might be excluded, whereas from the roentgenographic picture such a basis seems quite likely.

It is to be noted that the operation in this case was not undertaken on account of the osteitis condensans, but was indicated, in the opinion of the orthopaedic surgeon, on account of the disabling character of the pain.

SUMMARY

We have an unusual bone affection characterized by a smaller or larger area of dense sclerosis, occurring on the iliac side of the sacro-iliac synchondrosis, not involving the sacro-iliac joint, and definitely not due to osteo-arthritis.

The nature of the etiology is not clear; the pathogenesis is unknown; and the clinical significance is debatable.

It does not fall definitely within the category of any of the known bone diseases or affections, but the type of lesion in the region of the nutrient foramen suggests a low-grade inflammatory nature.

It is important, if only to avoid ascribing clinical significance to a condition that may be more in the nature of an incidental roentgenographic finding.

Osteitis condensans should be carefully looked for in all roentgenograms of the pelvis and, when found, the cases should be completely investigated so that, as new facts and findings are gradually uncovered, much that is now uncertain and vague will become clear, and another entity may be added to the list of bone affections.

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THE EFFECTS OF HYPERCALCAEMIA ON JOINTS

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Hyperparathyroidism has been produced experimentally in animals with a resultant disease picture simulating generalized osteitis fibrosa cystica [1, 5, 6]. However, no mention of intra-articular pathology has been found in the vast literature dealing with the experimental work on the parathyroid hormones. In the clinical field, Oppel, in 1929, directed attention to the possible relationship which may exist between the ankylosing type of polyarthritis and hyperfunction of the parathyroid glands associated with hypercalcaemia and hypo-electro-excitation of the muscles. Partial parathyroidectomy was performed on forty-nine patients suffering from this condition, and thirty-three of them showed improvement with disappearance of the hypercalcaemia. Funsten, in 1933, also reported encouraging results following partial parathyroidectomy in fourteen arthritic patients with hypercalcaemia. After operation, thirteen of his patients showed marked improvement and nine of them were entirely relieved from symptoms.

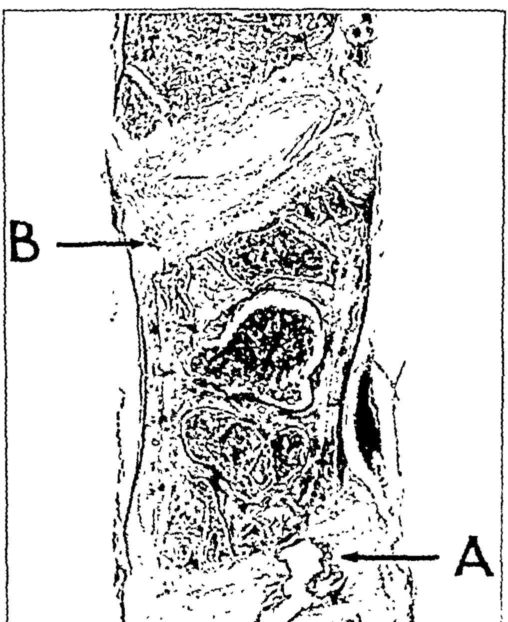

FIG. 1

Photomicrograph (× 29.5) of intervertebral disc, showing a large cystic space (*A*) with deposits of calcium at its periphery. Excessive calcium (*B*) is also shown at the margin of the other disc.

It is well known that the feeding of large doses of vitamin D produces a high content of calcium in the blood[4,7,10] and resultant changes in the bones of experimental animals similar to those produced by the administration of parathormone [3, 8]. The exact mechanism by which these changes are brought about by vitamin D is not entirely understood. Taylor, Weld, Branion, and Kay believe that vitamin D acts through stimulation of the parathyroid glands by

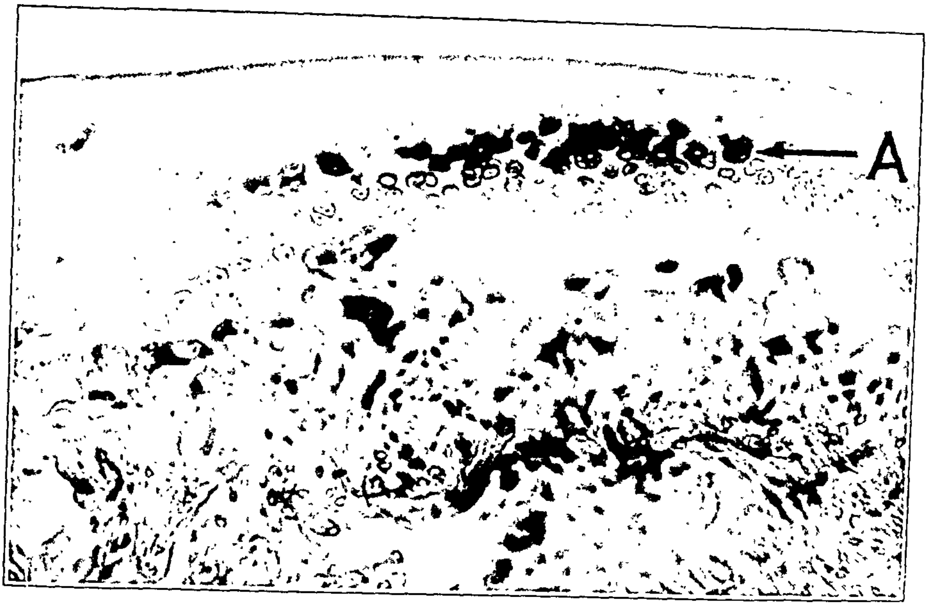

FIG. 2

Photomicrograph (× 120) of cartilage on the lower end of the femur, showing deposits of calcium (*A*) in its intermediate area.

the sterol. Johnson and others believe that vitamin D either stimulates the parathyroid glands to secrete more hormone, or intensifies the activity of the hormone in circulation, or supplements the effect of the hormone.

The object of the following experiments was to produce a prolonged hypercalcaemia through the feeding of large doses of vitamin D and to study the intra-articular structures for possible evidence of arthritic changes.

In the experiment, fifteen female albino rats, aged four weeks, were employed. The animals were divided equally into five groups of three each. The food for all animals consisted of the usual rat diet of corn bread, wheat flour, and cabbage. Those of Groups I, II, III, and V received normal amounts of this food and those of Group IV received only half the normal amount of food. The rats of Groups IV and V did not receive irradiated ergosterol and, therefore, served as control animals; in addition, it was possible to compare the changes resulting from malnutrition with those produced by hypercalcaemia. Each of the three animals in Group I was fed two milligrams of irradiated ergosterol daily; each in Group II, three milligrams daily; and each in Group III, five milligrams daily. The drug in the form of powder was mixed thoroughly with a very small portion of each meal. After the animal had consumed all of this small portion the remainder of the meal was given. Roentgenograms of all animals were made at weekly intervals. At autopsy, gross and microscopic examinations were made of the visceral organs such as the heart, aorta, lungs, liver, spleen, kidneys, adrenal glands, ovaries, thyroid and parathyroid glands, and on joints such as the knee and the spine.

The animals of Group I (fed with two milligrams of irradiated ergosterol daily) gained weight and showed no external or roentgenographic

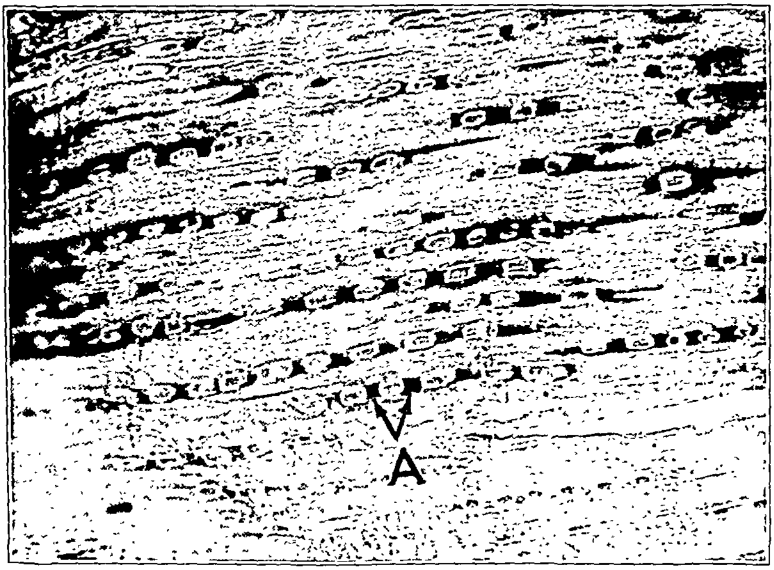

FIG. 3
Photomicrograph (× 210) showing a longitudinal section of the lateral ligament of the knee joint. Note the calcification (*A*) between the cells.

changes when compared with those of Control Group V. The animals in Groups II and III (fed with three and five milligrams of irradiated ergosterol daily) showed, in roentgenographic studies, marked decalcification of the skeletal system with cystic changes at the ends of the long bones as early as the third week after the administration of the drug. They became less active and very irritable on being disturbed; also, they failed to gain weight and some of them even lost weight. The animals in Group IV remained stationary in weight; their long bones, however, revealed diffuse absorption of calcium, but without the characteristic cystic changes at their ends.

At the end of six weeks an autopsy was performed on one animal of each group. Gross examination showed calcium deposits in the aorta in the animals from Groups II and III, and diminished resistance of the long bones to cutting in animals from Groups II, III, and IV. No other changes could be observed by the naked eye. Microscopic examination also revealed marked changes in the animals of Groups II and III. In the aorta there were extensive calcium deposits which, in places, occupied the entire circumference of the media. Calcification was noted in the heart muscle, just beneath the endocardium and near the valves. Also, calcareous deposits were seen in the arteries of the heart, lungs, and skeletal muscles and occasionally those of the liver, the spleen, and the kidneys. In various places the cartilage of the intervertebral discs showed deposits of calcium. In one place, the disc showed a large cystic space which was heavily lined with calcium and, as a result of this degeneration of the disc, the intervertebral space was markedly narrowed (Fig. 1). In the knee

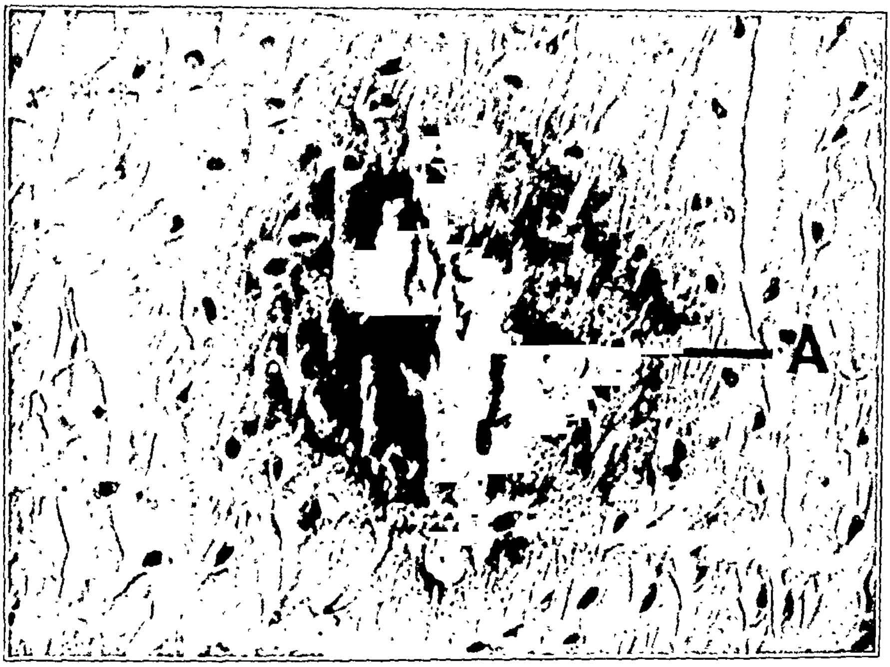

FIG. 4

Photomicrograph (× 298) showing a cross-section of the lateral ligament of the knee joint. Note the dense area of calcification (*A*) in the center of the field.

joints, several interesting observations were made. Deposits of calcium were seen in several sections of the central or weight-bearing portion of the cartilage (Fig. 2). The epiphyseal bodies which extend into the joints showed characteristic changes such as diffuse atrophy and enlarged marrow spaces. The synovial membrane showed normal findings, except for occasional areas of calcification of the larger arteries contained therein. The lateral ligaments of the knee joints also exhibited irregular areas of calcification (Figs. 3 and 4). The most marked calcium deposits were seen in the large para-articular collateral vessels. The microscopic findings in the case of the animal from Group I did not differ in any respect from those of the Control Groups IV and V.

At the end of twelve weeks an autopsy was performed on another animal of each group. The animals from Groups II and III showed pathological changes similar to those found after six weeks. Again, nothing of interest was found in the animals of Groups I and IV.

After the twelfth week the remaining animal in Group III was placed on a normal diet, without irradiated ergosterol, following which it gained weight rapidly and gradually recovered its normal appearance. Three weeks later, the animal was sacrificed and no trace of calcification could be found in any of the organs, and examination of the bones and joints showed normal findings. Autopsies were performed on the remaining animals of the other groups at the end of sixteen weeks, and the findings were similar to those seen in the other animals of the same groups after six and twelve weeks. Attention was directed toward the possible appearance of urinary calculi, with the result that numerous plaques of

calcium were observed in the smaller as well as in the larger blood vessels of the kidney and in the renal tubules. The parathyroid glands of the treated animals were sectioned in every case, but hyperplasia, adenomatous growth, or atrophy was not observed.

SUMMARY

In our experiments, chronic hypercalcaemia was produced in albino rats by prolonged administration of large doses of irradiated ergosterol. Characteristic osseous changes and metastatic calcification occurred chiefly in the blood vessels of various organs. The cartilage of the knee joints and of the intervertebral discs showed areas of degeneration with calcification,—changes not unlike those found in early degenerative arthritis of human joints. Calcification of the extra-articular collateral vessels of the knee joints was prominent, but probably of no specific significance, since the entire vascular system showed similar changes. There were no anatomical or histological changes in the parathyroid glands to support the contention of Taylor that vitamin D acts through the parathyroid glands.

The rat may recover completely from the effects of prolonged feeding of vitamin D within two to three weeks after the drug is withdrawn.

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FRACTURES IN PAGET'S DISEASE

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Our purpose in reporting the following eight cases of fracture in Paget's disease of bone is to discuss the frequency of this condition, the type of fracture, and the results of healing properties, and to review the literature, which is not extensive.

CASE 1. E. F. H., male, aged sixty-five, was examined on account of moderate pain and lameness which involved the region of the left hip. The roentgenograms showed definite Paget's disease involving the upper portion of the femur, especially about the greater trochanter. Three days later his physician reported that while stepping off a curbing the patient had fractured his hip. Another roentgenogram showed a transverse fracture through the trochanter without much displacement. The patient was treated by immobilization in a plaster cast, and union took place within two months.

This was a case of almost spontaneous fracture, caused simply by stepping off a curbing. The amount of pain was not great, and the case was not difficult to handle. The roentgenograms of this case are not reproducible.

CASE 2. J. F., male, aged fifty-seven, slipped on some ice as he was getting out of his automobile and felt his leg give way. He was brought to a hospital in an ambulance. He lay in bed with his left leg outwardly rotated. He was in moderate pain on being moved. Roentgenograms showed Paget's disease through the pelvis and upper left femur and a fracture, transverse and complete, just below the greater trochanter.

The patient was treated at first with a Thomas splint and skin traction, followed in three weeks by a plaster cast. He was very comfortable as soon as traction was applied. There was firm union in a reasonable length of time.

CASE 3. W. S. R., male, aged sixty-five, was known to have had progressive bowing of both legs for some time. His physician stated that the patient had stepped down one step and had fractured the right femur.

A roentgenogram, taken on admission to the hospital, showed a fracture of the midshaft of the right femur, without overriding. A few days later, while skin traction was being employed, displacement and overriding of one-half an inch occurred; this was reduced under skeletal traction. On account of the patient's mental condition, all traction had to be removed at the end of three weeks and he had to be put into a plaster spica.

He was seen two years later, and the fractured leg was then slightly longer than the opposite leg, because the bowing had been corrected too much. There was very little actual pain in this case, and union came quickly.

CASE 4. G. H., male, aged fifty-six, a railroad conductor, stepped off the train as it was moving slowly. As he did so, he felt a snap in the left lower leg.

He was admitted to the hospital and the roentgenogram showed Paget's disease, confined to the left tibia and fibula, and a complete transverse fracture of the lower and middle thirds of the tibia, without much displacement. There was very little pain and not much ecchymosis. The patient was not conscious of any trouble with his leg before the accident.

The leg was put into a plaster cast without anaesthesia, and in eight days the patient was discharged from the hospital on crutches. At the end of two months all apparatus was removed, and examination revealed good union.

About two months later, while walking in the railroad yard, the patient felt his leg give way and he received another fracture of the same tibia about four inches above the first fracture. This was not complete and it required a plaster cast for only a comparatively short time.

There is another patient (Case 6) in this series who sustained a second fracture.

CASE 5. J. R., male, aged sixty-one, while working as a longshoreman, was knocked down by a bale of wool. He received an injury to the cervical spine and fractures of the right tibia and fibula. On admission to the hospital he was in shock from the injury to his neck, and there was a queston of fracture of the cervical spine.

Roentgenographic examination revealed extensive Paget's disease, involving the whole spine and pelvis and the lower legs. The fracture was transverse and slightly comminuted.

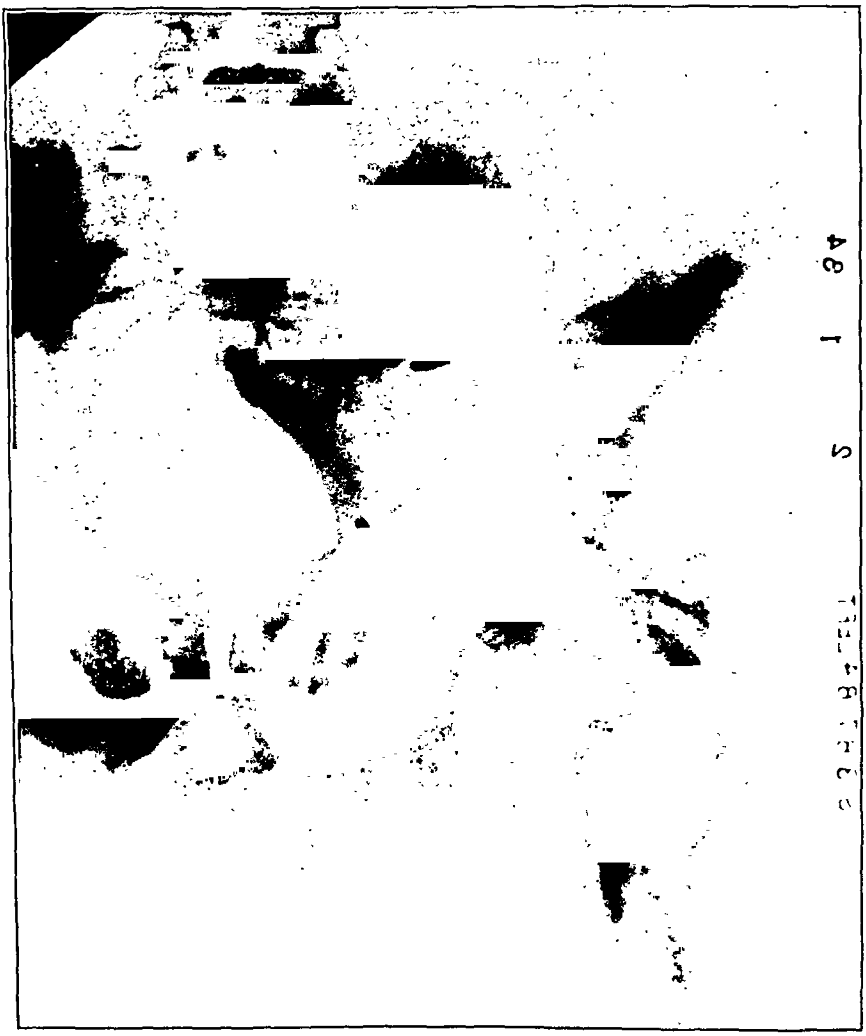

FIG. 1

Case 2. Transverse fracture with overriding.

On account of the extensiveness of the changes in the spine, a complete blood analysis was done, with especial reference to calcium, phosphorus, and phosphatase, and the findings were normal. This was done to rule out other bone conditions.

Union was complete within three months.

CASE 6. W. F., male, aged sixty-two, while walking on the street in 1932, had suddenly felt his right leg snap as if something had given way. There had been no *actual pain. He had called a taxi and* had been taken to a hospital where examination had disclosed a complete transverse fracture of the middle and lower thirds of the tibia. The fragments had united readily.

In 1935, while walking along the street, the patient felt a snap and a tingling sensation, and the leg became weak, with very little pain. He went to a hospital and roentgenographic examination showed an *incomplete fracture of the upper* and middle thirds of the same leg.

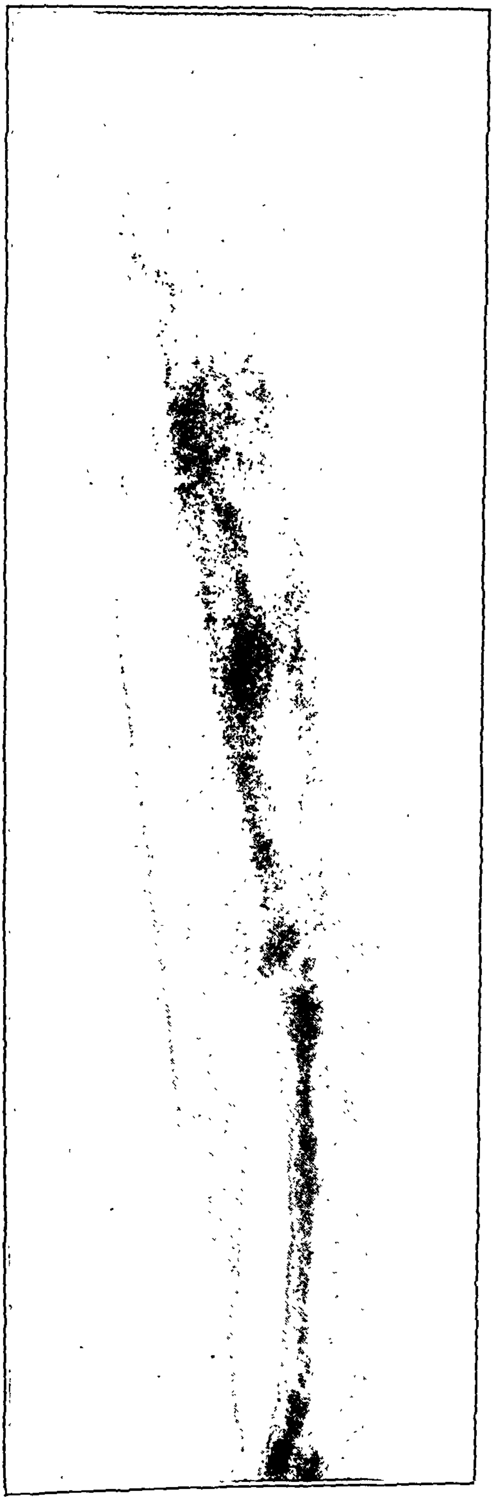

FIG. 2

Case 4. Lower fracture, complete; upper fracture, incomplete.

FIG. 3

Case 5. Extensive Paget's disease throughout the spine. Moderate changes in the *tibia and in the* fibula.

This case and Case 4 represent double fractures, the second being incomplete.

CASE 7. R. C., male, aged fifty-three, a letter-carrier, slipped on some ice and sustained a fracture of the patella. The exact mechanism of the injury is not known, but probably it was not an extreme trauma.

On taking roentgenograms, it was found that the patient had Paget's disease, involving the tibia and the patella. At operation, the capsule was sutured and the patellar fragments were held by catgut sutures through the fascia. There was fibrous union of the patella with resultant moderate loss of function. The patient was not able to resume his work as a letter-carrier. For this reason a second operation was performed in which fascia lata was inserted through drill holes in the patella. Nothing very startling was found on cutting down on the patella, except that there was very little bleeding from the bone. Sufficient time has not elapsed to know whether or not bone union will take place.

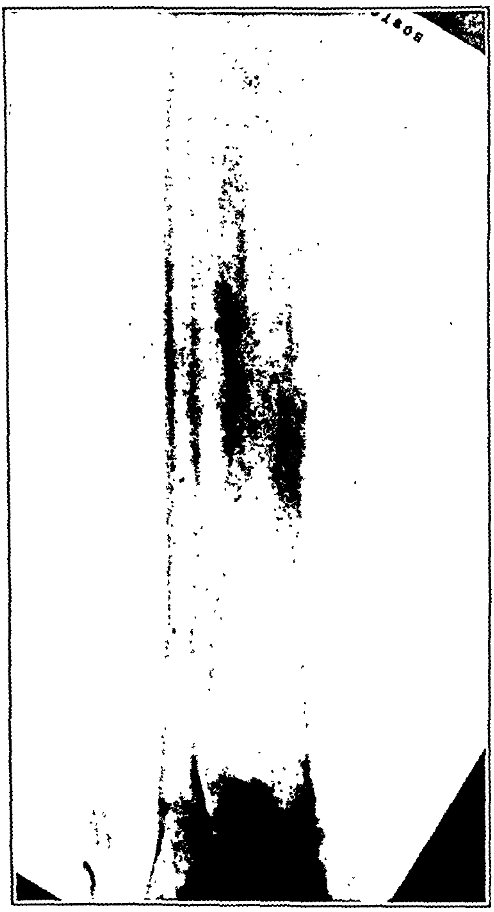

FIG. 4

Case 6. Lower fracture, received three years previously, shows fracture line. Recent fracture shows no displacement.

FIG. 5

Case 8. Very slight incomplete fracture line.

The following case is a very interesting one because it represents an incomplete fracture which could be very easily overlooked.

CASE 8. J. B. L., male, aged sixty, was known to have Paget's disease of one tibia. He was under treatment for diabetes and then had a mild hemiplegia, involving the right arm and leg. In three weeks' time he showed no evidence of spasticity. While standing, he began to dance to show how well he was when he felt a sharp pain below the knee. This kept him in bed for a month, and at first he was unable to raise his right leg. There was no hematoma and only slight local tenderness.

At the end of six weeks, after the patient had been up on crutches, roentgenograms showed an incomplete fracture line below the tibial tubercle. A possible fracture was masked by the other conditions, and the pain, weakness, and disability were supposed to be due to a circulatory condition. Of course, rest in bed brought about a good recovery.

In an analysis of these cases certain clinical facts are prominent. It is difficult to understand why such a process as Paget's disease with the gross thickening of the cortex should be subject to almost spontaneous or pathological fracture. This is discussed in the literature without any satisfactory answer being given. Only one of these eight patients (Case 5) was subjected to a violent trauma and, in this case, we are not sure that the injury to the tibia was extreme.

The absence of pain in these cases was quite noticeable. Case 5 is an illustration. All our attention was at first directed to the injury to the cervical spine, but, as soon as the patient was well over the shock, we felt that the position of the fragments of the tibia was not good enough. Therefore, the patient was anaesthetized and, with use of the fluoroscope, better reduction was attempted. On account of the type of fracture, the alignment was not improved, and the plaster was removed. The limb was then put on extension. It was possible to obtain better position and to manipulate better without anaesthesia, because the pain element was not prominent; the fragments could be manipulated without causing pain. The history of Case 6, in which the patient had a complete fracture and yet was able to get into a taxi to go to the hospital, is not quite the usual story.

In all of these cases there was a very definite tendency toward a transverse fracture, without comminution. Someone has likened this condition to the breaking of a peeled banana, which is quite apt. The two cases which simulated intertrochanteric fracture were really cases of transverse fracture of the shaft.

Every case showed normal, or probably better than normal, callus formation, and the care of these fractures was not difficult. The two cases which presented two fractures in the same tibia at different times (Cases 4 and 6) did not sustain the second fractures at the site of the original ones.

We have no means of determining from this series of cases the frequency of fractures in Paget's disease and the liability toward spontaneous fracture. Therefore it is improper to say that patients with Paget's disease should be warned of this possibility. No one has reported a large series of cases. It would be necessary to collect all the cases of Paget's disease that we have observed and then to take a percentage, but this would not be an accurate figure because personally we might be seeing the

cases of fracture without considering the disease as a whole. The frequency of such fractures might be 10 or 15 per cent. in our practice, and this is not true as a whole. The fact that so few writers have published more than three cases in their own series makes us believe that it is not a common occurrence. Therefore, we would not feel like warning patients of the possibility, without more evidence of frequency.

There is a difference of opinion as to whether Paget's disease renders bone more or less susceptible to fracture. Statistics regarding the incidence of fracture in Paget's disease give us little help in this respect. Hallerman states that he has never seen a spontaneous fracture in seventy autopsies of cases of Paget's disease, while Naville found twenty-five fractures in 170 cases of osteitis deformans in the literature. The latter finding is hardly a reliable index, inasmuch as the disease often goes unnoticed during life unless fracture takes place.

Ewald believes that fractures are uncommon in Paget's disease. He thinks that the bone is rendered more resistant to trauma by reason of its modified structure. It is thicker and there is a large amount of tough connective tissue which, together with decalcification, gives increased elasticity; consequently, under pressure the bone would tend to bend rather than to break. He, therefore, is of the opinion that most spontaneous fractures reported in the literature are not associated with Paget's disease but with Recklinghausen's disease (osteitis fibrosa cystica), which is pathologically similar to the former and is very susceptible to spontaneous fracture. Donati is of the same opinion as Ewald.

Other writers, basing their views on clinical impressions, believe that there is a greater fragility of the diseased bone in Paget's disease and that therefore this bone fractures more easily than normal bone. To substantiate this view, Oberzimmer describes twelve fractures (four observed personally—two of which were in one bone—and eight cases from the literature, reported by Kraas, Smith, and Looser) and concludes that, although spontaneous fracture may not be frequent, a minimal trauma may be responsible for fracture. Woytek reports seven fractures, four of which were spontaneous and three of which (occurring in one patient) resulted from minimal trauma. He concludes that the frequent occurrence of fracture in Paget's disease from trauma which would not ordinarily result in fracture of normal bone and the occurrence of repeated fractures in one individual with Paget's disease are evidence of increased susceptibility to fracture. Love reports three cases of spontaneous fracture, which he believes to be an uncommon complication in the absence of myelomatosis. Philips reports six pathological fractures; Le Wald describes four; Murphy, Konjetzny, Rocher and Pouyanne, Arnulf and Van der Linden, and Lewin each report one case.

Although the traumata in most of the reported cases were indirect in character, the resulting fractures, as shown by roentgenograms, were transverse and without spicules rather than oblique or spiral. Ewald and Looser both describe the appearance very appropriately as resembling "a peeled banana broken in two".

Little consideration has been given in the literature to the element of pain in these fractures. Murphy does make special note of the "absence of severe pain"; Ewald states that the fractures may be painless; and Rocher and Pouyanne, in their case history, remark that the patient had "slight pain".

As for healing, there is practically general agreement that callus is laid down rapidly and union usually takes place in the normal length of time.

CONCLUSIONS

1. In spite of the gross thickening of the long bones in Paget's disease, there is a definite tendency to fracture, which is generally caused by slight trauma.
2. There is a definite loss of sensation of pain, so that these fractures can be easily handled.
3. There is an early appearance of callus and new bone formation.

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THE PATHOLOGY AND TREATMENT OF TENNIS ELBOW

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A condition, the symptoms and signs of which are as constant as those of tennis elbow, may well be supposed to have but one pathology and, as a corollary, but one type of treatment. The purpose, then, of this paper is to present a synopsis of the opinions held on the pathology of tennis elbow and to single out the most probably correct. Further, an attempt is made to reconcile apparently contradictory views on treatment and to promote the adoption of a simple and quick method.

PREDISPOSING FACTORS

Work or play which entails repeated pronation and supination movements with the elbow almost fully extended is essential for the development of a tennis elbow; those patients who remember no special overexertion will be found to be working at screwing, lifting, hammering, ironing, etc., or to be violinists, surgeons, masseurs, etc.

Cubitus valgus, mentioned by Preiser [22], is obviously important, but many patients do not show it. Of course, the smaller the carrying angle the greater will be the strain on the outer side of the elbow joint when the extended forearm is vigorously supinated or when a weight is carried with an extended and supinated forearm. The roentgenograms reproduced in various articles often show considerable valgus,—*e.g.*, Merlini's [57] Case 2, Bergmann's [49] Case 2.

Rheumatism,[3, 63] suppressed gout,[3, 19] the arthritic diathesis, and focal sepsis [28, 68, 69, 80, 88] have all been suggested as determining the chronicity of the lesion in tennis elbow, once it has occurred. Though these may have some bearing in the older patients, they are probably coincidental, since treatment to the elbow alone clears the condition up permanently. Moreover, other chronic conditions about joints—golfer's elbow and rider's sprain are the most analagous—are not considered due to anything but the original trauma, and it is clearly only the long duration and the refractoriness to treatment that have suggested these contributory factors. When the general adoption of adequate treatment has lessened the period of disability, little will probably be heard of this theory.

DURATION

The condition usually clears up in eight to twelve months without any treatment except perhaps avoidance of the painful movements for a time. Cases lasting much longer, however, are encountered. Merlini [57] described two cases in fencers, which lasted seventeen and twenty years respectively; Ochsenius's [53] patient, however, who was supposed to have had a tennis elbow for twenty-seven years, cannot be included, since he

was treated after two years' disability by iodoform injections into the joint under the mistaken diagnosis of a tuberculous arthritis. When last seen he had a marked osteo-arthritis of the elbow and showed Preiser's incongruence. Others have reported durations of from four to six years,—Couderc [10], Tavernier [44], and Ferrero [58].

FREEDOM FROM RECURRENCE

A tennis elbow, once it is well, does not tend to recur. This is the common experience of everyone, but the fact has never been stressed. Although an ordinary muscular stiffness (Clado's *"courbature"* [15]) may pass off completely and return on exercise, no case of recurrence after full development of the syndrome has ever been reported. Hansson and Horwich [74] mention two patients, both Davis-Cup players, who were free from symptoms six and fourteen years respectively after recovery. Knoll [82] found that six out of forty-one international players had had tennis elbow and had recovered, so that it would almost appear to be a condition to be expected, borne, and recovered from in the course of training among this class of sportsmen.

Further information on this point was obtained by an inquiry sent to those authors who had cited themselves as sufferers. Six replies were received (see References) in all of which recurrence was denied after the lapse of seven, nine, thirteen, thirteen, twenty-two, and twenty-four years respectively, although the game or work responsible had been resumed as soon as the elbow had become well.

POSITION OF AREA OF MAXIMUM TENDERNESS

This has been variously stated as:

1. On the tip of the epicondyle (most authors);
2. On the posterior surface of the epicondyle (Fisher [60]);
3. On the anterior surface of the epicondyle (Vulliet [21], Tavernier [44]);
4. On the radiohumeral joint line (Trethowan [71], Bankart [83]);
5. On the capsule of the elbow joint (Preiser [17], Glass [65]);
6. Above the epicondyle (Bertocchi [54], Ogilvie [66]);
7. Over the radio-ulnar joint (Fisher [60]).

Since the precise position is of importance for the elucidation of the pathology, particular care was taken in the writer's series to determine this accurately. Of the twenty-two elbows reported here, twenty were tenderest on the anterior aspect of the lateral epicondyle, one on the apex of the epicondyle, and one on the extensor bellies. Nearly all were more tender on the radiohumeral joint line than on the *apex* of the epicondyle,—a fact which may account for the statement that the tenderness is greatest on the joint line, for the anterior face of the epicondyle is not easy to get at and can be palpated firmly only with the elbow flexed. Occasionally the radiohumeral capsule was slightly tender; in no case

was the head of the radius tender. Pressure on the most tender area gave rise to the typical referred pain down to the back of the wrist. Careful palpation here shows that the tenderness is where the lateral part of the common extensor tendon arises from the bone; the finger is not directly on the bone, but on the almost as hard tenoperiosteal junction, just medial to the ridge formed by the edge of the tendon.

VARIETIES OF TENNIS ELBOW

I. *Acute—Following Indirect Trauma*

The disability dates from an acute pain and the feeling of something giving way at the elbow during the performance of a violent action. On the outer side of the forearm, just below the epicondyle, a swelling appears which subsides in a week or less. Only once in the whole literature has bruising been noted [15]. The tenderness is on the upper part of the extensor bellies in the forearm and the lesion is almost certainly a muscular rupture. Heald [80] states that cases of sudden onset show tenderness chiefly of the muscles. Rosenburg [52] has reported a rupture of the extensor carpi radialis longus: the onset was sudden; swelling was present; and the patient became perfectly well in two and a half years without treatment. The writer reports a similar case, but such cases are uncommon.

II. *Subacute—Following Indirect Trauma*

This is the typical variety, usually found in younger patients. The onset is gradual and follows vigorous exercise with the arm. The symptoms subside when the elbow is rested, but reappear with more intensity when the game is resumed until finally the patient can hardly turn a door-handle or lift a teapot. The syndrome may take a few days or weeks to reach its zenith, and spontaneous cure is probable in the end. The tenderness is on the epicondyle.

III. *Chronic Occupational*

One or more months may be required for the full development of this type, which is usually found in older patients. Often no history of an injury is obtainable, but the patient's occupation at once provides the clue. Although the pain and disability are not so severe as in the acute variety, the tendency to spontaneous cure is less than in the acute type.

IV. *Following Direct Trauma*

Thirteen cases of development of a tennis elbow after a direct injury to the lateral epicondyle have been reported (Momburg [23], Coues [29], Dubs [38], Jungmann [47], Fischer [48], Frey [59], Bryce [73]), and the writer describes another. Furthermore, in Carp's [51] Cases 3 and 7 a radiohumeral bursitis developed after a direct injury to the outer side of the elbow. As a rule, in severity and duration they resemble the chronic variety described. Since no tear of ligaments, muscles, or tendons can occur

as the result of direct injury, this variety is important because of the light it throws on the pathology.

TREATMENT

UNCERTAIN TREATMENTS

Only a list of these treatments will be given as they are of small significance and have little effect on the course of the disability. They include: rest, strapping, pressure pads, painting with iodine, etc., blistering, hot baths, hot air, luminous heat, galvanism, faradism, diathermy, cauterization, ionization, ultra-violet light, x-rays; injections of alcohol, carbolic acid, or novocain; removal of focal sepsis; vitamin D, thyroid gland, salicylates, given internally.

Massage is regarded as definitely harmful by some (Vulliet [21], v. Goeldel [30], Bergmann [49], Edgar [63], Mau [77], Hohmann [85]) and is advocated by others (Rivière [12], Bähr [14], Clado [15], Preiser [17], Cooke [42], Romer [43]), particularly by Bankart [83] and Tucker [88] who advise deep massage to the painful area. A periostitis visible in the roentgenogram is generally regarded as an indication for immobilization.

SUCCESSFUL TREATMENTS

No Treatment

As has already been mentioned, spontaneous cure is probable by the end of eight to twelve months. Keeping the arm in a sling does not appear to help much, probably because the natural position for the forearm held thus is pronation with the wrist flexed; the extensor muscles are therefore not relaxed.

Cock-Up Splintage

This is a most rational way of relaxing the extensor muscles and of allowing healing to take place uninterruptedly. Hansson and Horwich [74] adopted it in sixteen cases and obtained cure in twelve. In only two cases had the disability lasted more than ten weeks: six months in one which terminated successfully; two years in the other which resulted in failure. The average period during which the splint was worn was thirty-two days with extremes of sixty-seven and eight. Only two patients were under forty years of age. Spitzy [75] proposed relaxing the extensors still more by splinting the fingers in extension and the elbow at a right-angle as well, but Mau [77] found the fingers to be so stiff afterward that he advised against this elaboration. Ordinary cock-up splintage appears, therefore, to be a cheap and effective, if a somewhat slow and cumbersome, method of treatment, most suited to the recent case. Should the writer's opinion on the pathology be correct, this treatment is open to the theoretical objection that it makes recurrence possible, since healing without lengthening will probably occur.

Mobilization

Only the English authors advise this treatment (Romer [43], Mills [56], Fisher [60], Edgar [63], Ogilvie [66], Trethowan [71], Marlin [72], Bryce [73], Bankart [83],

Mennell [87], and Tucker [88]). They are all agreed that in chronic neglected cases mobilization is the correct treatment. Trethowan and Ogilvie regard mobilization as having no place in the treatment of the recent case and Heald [80] considers it harmful if used too soon. Verrall [67] states that Mills's manipulation cures a third of the cases in which it is tried, while up to 1928 Mills had not had a single failure. Mills was always able to obtain a crack or a click from the elbow when it was mobilized. Ogilvie found that when no click was elicited, the elbow was not cured. Marlin states that the snapping noise is without significance and can always be produced in the other elbow. Mills stands alone in advocating mobilization in the acute as well as in the chronic stage. He points out that not all tennis elbows can be caused by adhesions and mentions a patient whose elbow "went out"; the elbow was mobilized at midday and the patient could play again the same afternoon.

The mobilization itself consists of various modifications of forcing full extension at the elbow. The method most usually adopted is undoubtedly Mills's,—with the forearm fully pronated and the wrist and fingers flexed, the elbow is forcibly extended; thus the greatest possible pull is exerted on the muscles attached to the lateral epicondyle. Bankart advises the same in the reverse order; Marlin, extension at the elbow with the forearm in the midposition; Bryce, pure extension. Tucker mentions Mills's procedure combined with pressure to produce a cubitus varus and, in addition, suggests forced full extension at the elbow with the forearm supinated and adducted. There is general agreement that anaesthesia is helpful and usually necessary; the mobilization is hardly ever repeated.

It is interesting to note that though mobilization, particularly by Mills's method, is the very reverse of cock-up splintage, both are advocated for the same condition, and by some, even for the same stage of the same condition.

Periosteal Excision

This method has been practised by Franke [20], v. Goeldel [30], Fischer [48], Bergmann [49], and Merlini [57]. Fischer's Case 7 is particularly interesting in that he first removed the subcutaneous fascia and fat over the lateral epicondyle and, when the patient failed to benefit, operated again and removed the epicondylar periosteum, this time effecting a cure. He regularly obtained good results with this method and described four cases of immediate relief after excision. However it is not possible to assess the value of this operation as the number of patients operated on and the late result are not given by all these authors, but its effect is doubtless the same as that obtained by Hohmann's operation. That it is not always successful is shown by Merlini's Case 4 in which the patient was relieved for only six months.

Division of the Muscular Origin at the Epicondyle

Hohmann [55] describes this operation (first practised by Codman [43]

over fifteen years ago), which effectively relieves the tension on the epicondyle and allows the inflammation to resolve undisturbed. He exposes the epicondyle and divides the muscular attachment on the front of it,—chiefly the origin of the extensor carpi radialis brevis. Fourteen of Hohmann's fifteen patients were cured within a week of the operation, and Mau's four patients, aged thirty-eight to fifty-five, remained well after intervals of one, two and one-half, three, and three years respectively. On the other hand, Gebhardt [84] has seen three cases of this operation, in all of which recurrence began at the end of a year. The grip was not weakened afterward. If cock-up splintage and mobilization have both failed to relieve a patient, Hohmann's operation appears to the writer to be the best and the most reasonable.

Bursting or Removing a Bursa

Schmitt [39] described a case of stiffness in the left elbow lasting for four years, a swelling of two years' duration, and pain persisting for three weeks, caused by a calcified bursa at the lateral epicondyle visible in the roentgenogram. This bursa was removed. Osgood [40] reported three cases, in two of which immediate and lasting relief followed excision of the radiohumeral bursa. Dittrich [62] also removed one, thereby curing his patient, who remained well five months later. Carp's [81] contribution to the study of this condition is most important; he collected eight cases of radiohumeral bursitis, in five of which the calcified bursa was visible in the roentgenogram; in four of these the bursa disappeared after treatment. Digital pressure calculated to burst the bursa led to a dramatic and permanent cure in four; one bursa was excised. Rest and heat for from three to six weeks sufficed to relieve the remaining three patients, two of whom were still well one and five years later. Howell's [68] one patient refused operation.

Therefore, on the rare occasions when the physical signs suggest the presence of an inflamed bursa, bursting by digital pressure appears the best treatment; if this fails, rest and heat or excision will be indicated according to circumstances.

Disengaging or Removing Synovial Fringes

By 1929 Trethowan [71] had removed hyperaemic synovial fringes in the *radiohumeral* joint on eight occasions, with cure in all. Fisher [60] has described a manipulation partly designed to set free nipped synovial fringes in the *radio-ulnar* joint. While the joint is extended from the position of full flexion, quick pronation and supination movements are made; at the same time pressure is exerted on the outer side of the elbow. In all of Trethowan's patients the tenderness was greatest on the antero-lateral aspect of the radiohumeral joint line, and in chronic cases which show this sign and which are refractory to other treatment the joint may well be opened with the intention of removing a synovial fringe.

The Writer's Method

This has the merit of being simple and quick, and it does not necessitate an anaesthetic. It is equally applicable to cases of some hours' duration and to those of some years' standing; it is not unduly painful; and it can be carried out by any masseur.

While the patient sits with the elbow held at a right angle and the forearm supinated, deep friction is applied to the anterior part of the lateral epicondyle; the patient's skin moves with the masseur's finger, so as to rub the superficial tissues on the deep structures. This is continued for five or ten minutes,—the more chronic the condition, the longer is the period of friction. The elbow is then mobilized. (Since the amount of lateral wobble at the elbow when the forearm is extended and supinated varies considerably from person to person, it is well to compare the two sides before beginning.) The elbow is as fully extended and the forearm is as fully supinated as possible. With one hand on the inner side of the elbow and the other on the outer side of the wrist, the masseur adducts the forearm on the arm with a sharp jerk toward a position of cubitus varus. A crack is usually heard, which is sometimes also obtainable from the other elbow, but the manipulation is just as effective if no sound is heard. There are no muscles capable of opposing this movement, so that anaesthesia is valueless except to avoid the pain, which in any case is slight. The deep massage to the tender area and the mobilization are repeated thrice weekly until the patient is well; one treatment is seldom enough. This is another argument against anaesthesia, especially as no more can be done with it than without it. After this treatment the elbow is often a little sore for an hour or two, but it then improves to far beyond the original state. In the writer's series an average of four treatments was enough to give complete relief, with extremes of one and nine. The offending work or play was resumed as soon as the patient was fit, in all cases by the time treatment ceased.

COMMENT ON TREATMENT

The fact that a particular operation gives complete relief is no proof of the correctness of the theory on which it is based. For example, Carter [50] operated on three elbows in search of a radiohumeral bursa, did not find it, and cured the condition. Ogilvie [66] has reported eight more such cases; Fischer [48], two; and Verrall [67] and Bankart [53], a further unspecified number. Again, Tucker [58], who does not mention radiohumeral bursitis among the possible pathologies of tennis elbow, recommends Osgood's operation in cases resistant to ordinary treatment.

Apart from the rare occasions when an inflamed bursa or, possibly, a hyperaemic synovial fringe is found and removed, all the rational treatments aim at preventing tension on the epicondyle. Relaxation of the extensor muscles can be insured by cock-up splintage, and local relief of tension is secured by separation of the common extensor tendon from the bone either by operative division or by pulling it off. According to the

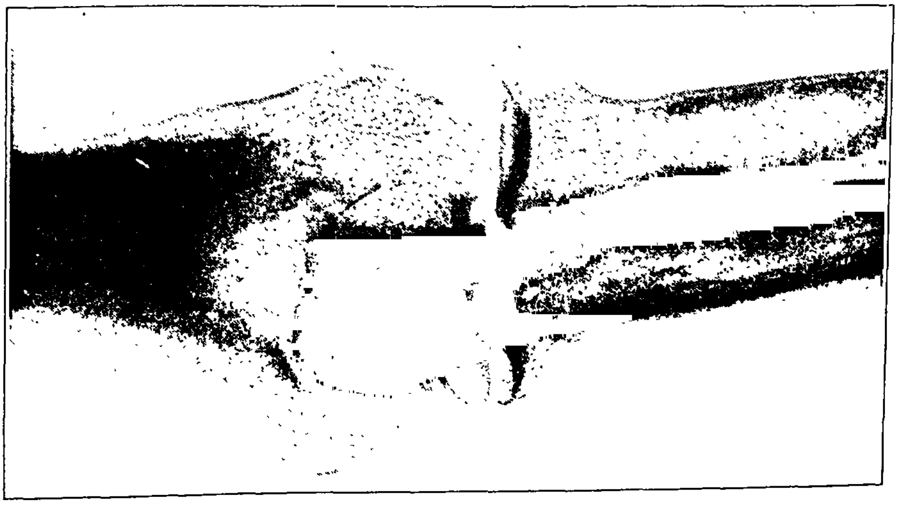

Fig. 1

Case 6. Right elbow four weeks after the injury. Note periostitis of the lateral epicondyle.

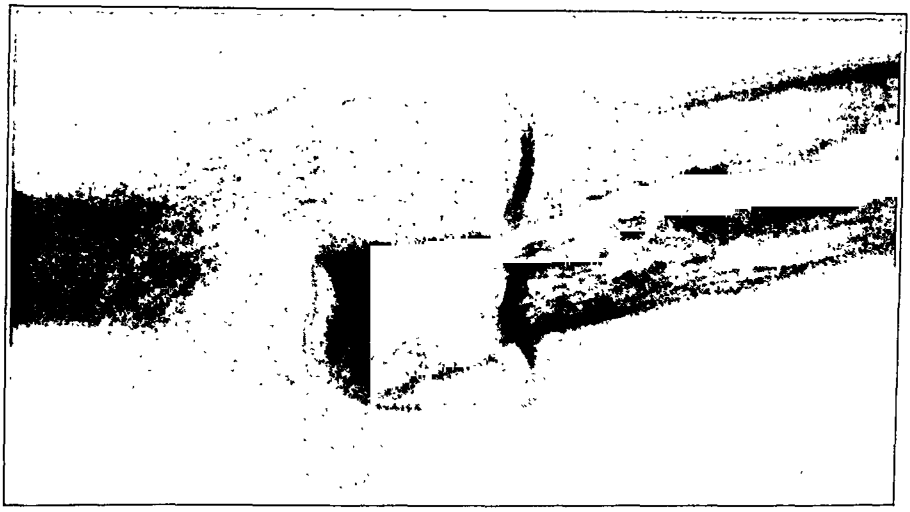

Fig. 2

Case 6. Four weeks after treatment—four mobilizations in eight days—had been finished. The patient was symptom-free during this period. Note much diminished density of epicondylar shadow.

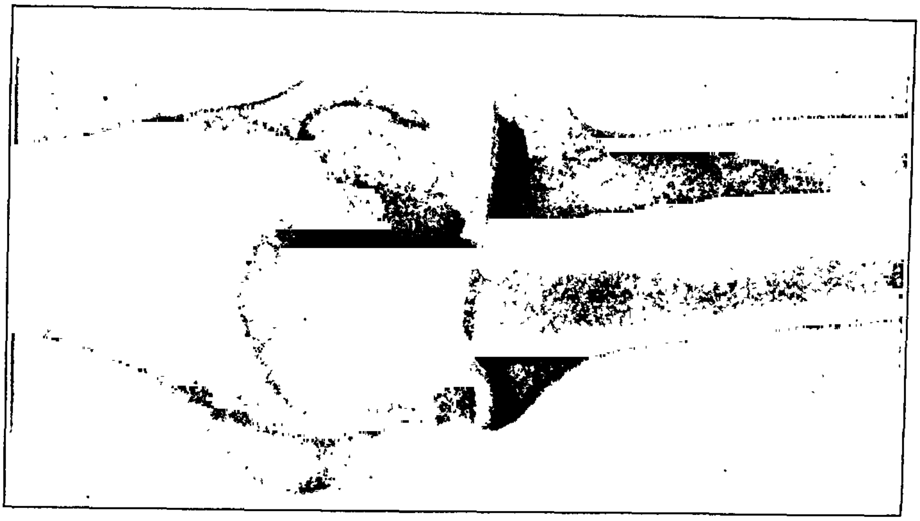

Fig. 3

Case 6. After six months of freedom from symptoms. Note slight diminution in size of the shadow.

TABLE I

SUMMARY OF CASES

Case	Sex	Age (Years)	Cause or Occupation	Duration of Symptoms	Side	Type	Cubitus Valgus	No. of Treatments	Duration of Treatment	Immediate Results	Late Results
1.	Male	45	Tennis	3 years	Right	Acute	None	6	1 month	Much improved.	After several months could play tennis painlessly.
2.	Male	23	Tennis	3 weeks	Right	Subacute	None	2	4 days	Full relief.	Untraced.
3.	Male	24	Tennis	7 months	Right	Subacute	None	4	10 days	Full relief.	4 months: still well.
4.	Male	35	Tennis	5 weeks	Right	Subacute	None	1		Full relief.	3 years: still well.
5.	Female	36	Badminton	4 weeks	Right	Subacute	None	3	5 days	Full relief.	16 months: still well.
6.	Female	47	Fall on hand	5 weeks	Right	Subacute	None	4	8 days	Full relief.	6 months: still well.
7.	Female	18	Carrying weight	8 days	Right	Subacute	None	1		Full relief.	8 months: still well.
8.	Female	48	Using spring-cutter in left hand	8 months	Left	Subacute	+	13	3 months	No improvement.	Wore a cock-up plaster on wrist 4 months, with full relief; 2 months later, still well.
9.	Female	34	Reining in horse	5 weeks	Right	Subacute	None	7	10 weeks	Full relief.	6 months: still well.
10.	Female	49	Carrying heavy stones	7 months	Right	Subacute	None	8	4 weeks	Nearly well.	1 month: full relief. 4 months: still well.
11.	Female	45	Carrying weight Housework	5 days 9 weeks	Left Right	Subacute Occupational	+ +	3 7	4 months 6 weeks	Full relief. Full relief. }	1 year: both elbows get stiff easily.
12.	Male	56	Violinist	36 hours	Right	Occupational	None	3	6 days	Full relief.	1 year: still well.
13.	Female	51	Housework	2 days	Left	Occupational	+ +	1		Full relief.	2 years: still well.
14.	Female	53	Chopping wood	3 years	Right Left	Occupational Occupational	None None	9 5	6 weeks 9 days	Full relief. Full relief. }	16 months: still well.
15.	Female	51	Housework	1 month	Left	Occupational	None	1		Full relief.	1 year: still well.
16.	Female	48	Lifting books	7 months	Right	Occupational	None	5	16 days	Full relief.	10 months: still well.
17.	Female	61	Lifting chair	5 months	Right	Occupational	+	5	3 weeks	Full relief.	6 months: still well.
18.	Female	59	Giving massage with painful shoulder	4 days	Right	Occupational	None	1		Full relief.	8 months: still well.
19.	Male	50	Pianist	5 months	Right	Occupational	None	2	3 weeks	Full relief.	5 months: still well.
20.	Female	45	Secretary	2 years	Left	Direct	None	3	6 days	Full relief.	2 years: still well.

TABLE II

ANALYSIS OF FINDINGS

Patients		20
Male	6	
Female	14	
Elbows		22
Right	14	
Left	4	
Both	2	
Age at Onset:		
Under 20 years		1
20 to 29 years		2
30 to 39 years		3
40 to 49 years		7
50 to 59 years		6
Over 60 years		1

writer, the success of mobilization in a case of tennis elbow depends upon the conversion of a partial tear of the tendinous origin into a complete tear; the epicondylar periosteum, now separated from the extensor tendon, is spared direct pulls, and healing with slight permanent lengthening occurs as it would in tendinous structures elsewhere. Cock-up splintage seems likely to be effective only in the recent case and may cause healing without lengthening. Mobilization and operative division of the extensor origin seem equally applicable to the acute and to the chronic cases.

PERSONAL CASES

Since 1932 the writer has treated twenty patients with tennis elbow. In two cases the condition was bilateral. The treatment was the same for all except one (Case 1 *) and was given three times a week whenever possible. Occasionally circumstances made it necessary to give treatments only twice a week or less. The average number of treatments per elbow (excluding Case 8) was four.

Only five of the twenty patients got well with a single treatment (compare with Verrall's statement of one-third). Neither the patient's age, nor the length of history, nor the variety of tennis elbow present enables a prognosis to be made of how many treatments will prove necessary, except that the acute type is apt to have a very chronic course. Of the twenty patients with twenty-two tennis elbows only one (Case 8) failed to get complete relief from the writer's treatment.

PATHOLOGY

This is the point on which the least agreement is found. A list has, therefore, been compiled of the various published opinions on this point.

* Treatment in this case consisted of kneading to the muscle bellies, deep friction to the olecranon fossa, and forced extension movements.

The mention of any author's name under a particular heading implies that he considers this pathology *one* of those possible.

1. *Traumatic Periostitis:* Runge [1], Remak [7], Bernhardt [8], Bähr [14], Momburg [23], Blecher [26], Worms [27], Coues [29], v. Goeldel [30], Sourdat [41], Cooke [42], Romer [43], Tavernier [44], Jungmann [47], Fischer [48], Bergmann [49], Carter [50], Bertocchi [54], Merlini [57], Ferrero [58], Frey [59], Fisher [60], Ogilvie [66], Hansson and Horwich [74], Mau [77], Heald [80], Hohmann [85], Boshamer [86], Mennell [87], Tucker [88], Brailsford [90].

2. *Arthritis, Synovitis, Sprain, Adhesions, or Torn Capsule of the Radiohumeral Joint:* Preiser [17], Kaufmann [32], Dubs [38], Glass [65], Ogilvie [66], Jones [70], Trethowan [71], Tucker [88].

3. *Arthritis, Synovitis, Sprain, or Adhesions of the Radio-Ulnar Joint:* Kaufmann [32], Mennell [34], Romer [43], Fisher [60], Trethowan [71].

4. *Displaced, Frayed, Torn, Inflamed, Orbicular Ligament:* Major [3], Coues [29], Romer [43], Mills [56], Ogilvie [66].

5. *Sprained, Torn, Radial Collateral Ligament:* Kaufmann [32], Little [33], Ogilvie [66], Heald [80].

6. *Inflamed or Calcified Radiohumeral Bursa:* Osgood [40], Dittrich [62], Carp [81].

7. *Inflamed or Calcified Subcutaneous Epicondylar Bursa:* Schmitt [39], Fischer [48], Howell [68].

8. *Nipped Synovial Fringe in Radiohumeral or Radio-Ulnar Joints:* Fisher [60], Ogilvie [66], Trethowan [71].

9. *Tear or Fibrositis of Extensor Origin:* Couderc [10], Romer [43], Mairano [45], Fisher [60], Bankart [83], Tucker [88].

10. *Tear or Fibrositis of Supinator Brevis:* Féré [11], Clado [15], Chastenet de Géry [28], Bryce [73], Heald [80].

11. *Torn Pronator Radii Teres:* Morris [2], Little [33], Bailey and Love [89].

12. *Torn Extensor Carpi Radialis Longus:* Rosenburg [52], Ogilvie [66], Heald [80].

13. *Torn Extensor Carpi Radialis Brevis:* Frey [59].

14. *Tear or Fibrositis of Brachioradialis:* Blecher [26], Cooke [42], Romer [43], Gebhardt [84].

15. *Tear, Sprain, Fibrositis of Extensor Digitorum Communis:* Fisher [60], Bankart [83], Mennell [87], Thomsen [91].

16. *Myositis or Tear of Extensor Muscles:* Féré [11], Edgar [63], Hansson and Horwich [74].

17. *Torn Anconeus:* Mennell [34].

18. *Radial Incongruence:* Preiser [22].

19. *Twist of Whole Radius:* Marlin [72].

20. *Rheumatism, Gout, Influenzal Sequelae, Focal Sepsis, Arthritic Diathesis:* Major [3], Duckworth [19], Franke [20], Le Clerc [25], Chastenet de Géry [28], Fischer [48], Frey [59], Edgar [63], Ogilvie [66], Verrall [67], Howell [68], Tucker [88].

21. *Neuritis of Radial, Posterior Interosseous, or Cutaneous Antebrachii Lateralis:* Winckworth [4], O'Sullivan [5], Molle [9], Marshall [18], Seeligmüller [35], Cooke [42].

22. *Saturnism:* Bernhardt [8], Osgood [40].
23. *Osteomalacia:* Mathez [61].
24. *Deposits about Olecranon:* Tucker [88].
25. *Periostalgia:* Frey [59], Conzette [76], Saxl [79].
26. *Osteochrondritis:* Spitzy [75].

COMMENT ON PATHOLOGY

In considering these rival claims, several barely disputed facts mu be borne in mind:

1. The onset is gradual;
2. There is no swelling or bruising;
3. A fully developed tennis elbow, once well, does not recur;
4. Except occasionally at the epicondyle, the roentgenogram revea no abnormality;
5. Only those individuals whose extensor muscles are strengthene by training or use develop the condition;
6. Direct trauma to the epicondyle can cause it;
7. When the elbow joint is opened, no abnormality has been see except a hyperaemic synovial fringe between the radius and th capitellum;
8. Excluding Osgood's and Trethowan's operations, the only effec tive treatments are those which relieve the tension on the epi condyle, and even these operations may have this effect, albei unintentionally.

After these points have been considered, there remain unexclude only three possibilities:

Affections of the Bursae

That a bursa exists at the lateral epicondyle and can become in flamed or calcified is proved by numerous roentgenograms (Schmitt [39]; Carp [81]), by the fluctuating swelling (Carp's Case 5; Howell [68]), by the glairy fluid released at operation (Osgood's [40] Case 2), and by the dramatic cure following bursting the bursa (Carp's Cases 1, 2, 3, and 4). Two different bursae, however, have hitherto been referred to as if they were identical: the subcutaneous bursa and that deep to the conjoined tendon, both of which exist and cause similar symptoms when diseased.

Schreger [93] discovered a bursa which he named the condyloidea humeri externa, the largest example of which was over an inch across. It is described by Gruber [94] as the bursa subcutanea epicondylica. He found its frequency to be once in sixty bodies at one or both elbows, and its maximum size to be one-half an inch by one inch. Vogt [96] and Bardenheuer [97] state that this bursa is the size of a hazelnut and emphasize its liability to inflammation. Again Schmitt [39], who regarded his patient as suffering from a sort of tennis elbow, called the bursa involved by Gruber's name. Fischer [48] also believed disease of the subcutaneous

epicondylar bursa to be a possible cause of tennis elbow. Those patients who have large fluctuating swellings over the lateral epicondyle must be suffering from an affection of this bursa (*e.g.*, Howell's [68] patient).

On the other hand, Monro [92] described but did not name a small bursa, three-eighths of an inch by three-sixteenths of an inch, lying between the common extensor tendon and the head of the radius. Gruber found it once in every six or seven bodies, lying under the extensor radialis brevis just below the epicondyle and in relation to the head of the radius; he called it the bursa musculi radialis externi brevis. This would appear to be the radiohumeral bursa of Osgood [40], Dittrich [62], and Carp [81], which the first named found to be present in eight out of nine dissections; it was small and lay under the conjoined tendon, below the epicondyle and level with the radiohumeral joint line. Grinnell found it in ten of eighteen bodies; it occurred bilaterally in five [81]. Heineke [95] distinguished between the two bursae in frequency and position. It is evident from the size and position of the radiohumeral bursa that fluctuation or an external swelling is not to be expected when this bursa is diseased.

Furthermore, there is a lack of conformity in the interpretation of the roentgenograms. For example, the roentgenograms of Jungmann's [47] and Bergmann's [49] cases of epicondylitis strongly resemble Schmitt's [39] case of a calcified subcutaneous epicondylar bursa and Carp's [81] Case 5 of radiohumeral bursitis; Worms's [27] case of an epicondylar spur over an inch long is very like Carp's Cases 6 and 7 with radiohumeral bursitis.

Nevertheless, the epicondylar spur continuous with the bone and the oblong shadow separate from it form two conditions obviously distinct.

In spite of the positive—and, in the writer's opinion, conclusive—evidence of the existence of the bursae, Trethowan [71] regards the radiohumeral bursa as nothing but a synovial pocket extending upward and outward from the radiohumeral joint toward the epicondyle. Fischer [48] thinks that the gap left when the fibers of the supinator brevis are separated from the capsule of the elbow joint may be mistaken for a bursa. Heald [80] says: "A minor injury of the supinator brevis—possibly involving filaments of the posterior interosseous nerve—near the radiohumeral joint, where the fibres have an intimate attachment to the joint capsule, might well account for the greyish-red nodules of Blundell Bankart, the bursa of Osgood, and the synovial protrusion of Trethowan. . . ."

Bursitis at the epicondyle, however, is a rarity. Osgood's paper in 1922 attracted a good deal of attention, but seven years later only one English case had been reported, and none have been recorded since. Altogether, twelve cases of bursitis have been collected in fourteen years, so that the subcutaneous epicondylar and the radiohumeral bursae can hardly be at fault in more than 1 or 2 per cent. of all the patients with tennis elbow. Moreover, judging by Osgood's account of his own symptoms and those of his patient (Case 3), by the fact that Howell's patient found ample relief from a band around the forearm, and by the complete

and lasting relief afforded to three of Carp's patients by rest and heat in from three to six weeks, bursitis is a mild form of tennis elbow.

Nipping of Inflamed Synovial Fringes

The only published cases are Trethowan's [71]. He opened the elbow in eight chronic cases and found hyperaemic synovial fringes between the radius and the capitellum; their removal was followed by cure. The writer has dissected six normal elbows and found that a long fringe, projecting well into the radiohumeral joint from the posterior part of the capsule, was present in all; anterolaterally this had become a slight ridge. Thus the mere existence of the fringe causes no symptoms; it must be nipped or inflamed before giving rise to disability. The curative effect of the operation does not prove that the removal of the fringe was essential, for the incision into the outer side of the elbow may have divided the taut structures attached to the epicondyle. (See "Comment on Treatment".) A nipping that continues for months and gives rise to symptoms in several positions of a joint with as many movements as the elbow is difficult to picture. In any case, should a non-operative method of freeing the nipped fringe be sought, the writer's manipulation—making, as it does, the radiohumeral joint gape—appears suitable. Nevertheless, it is hard to believe that an inflamed fringe could cause the symptoms of tennis elbow.

Tears of the Extensor Tendon from the Bone and Consequent Periostitis

This view on the pathology is the oldest, has far the greatest number of advocates, and is that favored by the writer. Much evidence points in this direction. Hansson and Horwich [74], experimenting with the gastrocnemius of frogs, found that a muscle tears most easily at its attachment to bone and not at its musculotendinous junction or in the belly itself. Since the position of maximum tenderness must indicate the site of the injury, the lesion in a tennis elbow occurs at the lateral part of the origin of the conjoined tendon from the epicondyle. No swelling or bruising is caused by tendinous ruptures, but crepitation may result and was felt at this point in two of the writer's patients. Further, since cock-up splintage of the wrist, leaving the fingers free, is a successful treatment, it follows that the tear involves the origin of the extensors of the wrist and not of the fingers. The origin of the extensor carpi radialis longus is almost wholly above the epicondyle and that of the extensor carpi ulnaris lies deep to the common extensor of the fingers, while the extensor carpi radialis brevis is the most lateral of the muscles springing from the epicondyle. Therefore, the pathology of the typical variety of tennis elbow is a tear between the tendinous origin of the extensor carpi radialis brevis and the periosteum of the lateral epicondyle. This explains the curative effect of Hohmann's [85] operation in which the origin of only the extensor carpi radialis brevis is divided. Corroboration of this theory is found also in the fact that active extension of the

wrist by a patient with a tennis elbow causes him more pain when it is resisted on the heads of the metacarpals than when the pressure is applied on the tips of the extended fingers.

Tendons usually heal with some lengthening; this explains the freedom from recurrence, since the intact muscles, chiefly the extensor carpi radialis longus, will in future take the greater strain. That the origins of this muscle and of the brachioradialis can be involved as well is suggested by the roentgenograms reproduced by Tavernier [44] and Bertocchi [54]. The gradual onset is explained by the fact that not until healing has begun and there is some adhesion between the torn tendon and the inflamed periosteum does the pull of the muscle cause pain. Then, of course, the inevitable repeated muscular jerks quickly start a chronic periostitis. That such a localized periostitis is not of itself painful is shown by the painlessness of the arm at rest and on passive movement, and by the fact that the epicondyle remains tender for some weeks after complete symptomatic relief has been obtained by the writer's method. The periosteum remains inflamed, but movement is not painful, owing to the separation of the tendon from the periostitic area. This effectual rest allows the inflammation to resolve. In the writer's Case 6, the periostitis was still visible on the roentgenogram six months after symptomatic cure. Moreover, the periostitis set up by a direct injury to the epicondyle may not subside if the extensor muscles are constantly used; whether or not a tear occurs, the condition is a periostitis at the epicondyle maintained by the constant pull of the muscles attached to it.

Proofs that a periostitis occurs are not lacking. It has been seen on the roentgenogram many times: as a spur at the point of the epicondyle from one-eighth of an inch to over an inch long (Blecher [26], Worms [27], v. Goeldel [30], Jungmann [47], Fischer [48], Bergmann [49], Merlini's [57] Case 2, Mau [77], Knoll [82], the writer); as a periosteal thickening running from the epicondyle up the outer side of the shaft of the humerus for two and two and one-half inches (Tavernier [44], Bertocchi [54]); as a series of little spicules of periosteal bone at and below the epicondyle, but extra-articular (Sourdat [41], Merlini's [57] Cases 3 and 4, Ferrero [58]). Hohmann [85], Boshamer [86], Tucker [88], and Brailsford [90] all agree that a periostitis at the epicondyle is sometimes seen, but they do not cite personal instances. As a rule, a periostitis is seen only after months or years of disability, but the roentgenograms of Case 6 show a periostitis at the lateral epicondyle after an injury only four weeks previously, which persisted for six months after symptomatic relief. Sometimes a diagnosis of periostitis is made on roentgenographic appearances that are more probably those of a bursitis.

Microscopy of the excised periosteum has shown definite inflammation (Franke [20], v. Goeldel [30], Merlini [57]); Bergmann [49] removed in addition a piece of the muscle attached to the periosteum, but found evidence of inflammation only in the latter; but in one case Thomsen [51] found evidence of chronic inflammation in an excised strip of the belly of the

extensor digitorum communis. However, in Fischer's [48] Cases 3 and 9, although cure followed periosteal excision, the microscope revealed no abnormality.

The occurrence of a periostitis—visible both on the roentgenogram and at microscopy—in some cases, then, is not in doubt. In the writer's opinion, *when the rupture is at its usual site*—the tenoperiosteal junction—the subsequent periostitis is not visible on the roentgenogram; it is seen only when an actual tear has taken place in the periosteum as well.

CONCLUSIONS

1. The evidence is overwhelmingly in *favor* of a typical tennis elbow's being caused primarily by a tear between the tendinous origin of the extensor carpi radialis brevis and the periosteum on the anterior surface of the lateral epicondyle. Secondarily, the continual jerks given to this area of acute traumatic inflammation by muscular contractions set up a chronic periostitis here, and to this the symptoms are referable. The acute periostitis occasioned by a direct injury to the epicondyle can become chronic for the same reason, notwithstanding the absence of a tear. Inflammation of the subcutaneous epicondylar bursa and of the radiohumeral bursa is an uncommon but well-defined entity capable of causing the symptoms of a tennis elbow. Ruptures of a muscle belly are very rare and differ neither in pathology nor in treatment from the same condition elsewhere. The possibility of a nipped synovial fringe's being at fault has yet to be proved.

2. The treatment described—deep friction to the tender area, followed by forced adduction of the extended and supinated forearm—has, in the writer's hands, given complete and lasting relief in an average of four treatments (extremes of one and nine), representing a period of eight to fourteen days. Good results followed the treatment of acute and chronic cases (extremes of thirty-six hours and three years), in the old and in the young (extremes of sixty-one and eighteen years), in a case of periostitis visible on the roentgenogram, and in a case due to direct injury to the epicondyle. The method should be adequate in cases of bursitis where bursting is possible; it is unsuited to muscular ruptures which should be treated on general lines,—*i.e.*, by kneading and stretching the belly involved.

3. Mobilization is theoretically justifiable in all cases of typical tennis elbow, *because the tendon is thereby pulled off* the chronically inflamed epicondylar periosteum to which it is adherent; thus the latter is spared the continual minor traumata which are maintaining the periostitis. Once this is effected, complete symptomatic relief will follow, even though the inflammation at the epicondyle has not yet subsided. Moreover, the writer's treatment is the most convenient from the patient's point of view,—it takes only fifteen minutes every other day; it needs no anaesthetic; and it in no way interferes with the patient's ordinary activities.

Furthermore, since healing with permanent lengthening is insured by this method, recurrence is most improbable.

4. Failing mobilization, the best treatment for the recent case appears to be a simple cock-up splint worn on the wrist day and night. In three-quarters of the cases complete relief may be expected in an average of a month's time. The success of this method depends on the relaxation it insures of the extensor carpi radialis brevis, whereby its tendon of origin and the epicondylar periosteum are kept in apposition and allowed to heal together without interruption.

5. All the operations described—on whatever theory they are based—are successful whether or not the elbow joint is opened. Of these, simple division of the origin of the extensor carpi radialis brevis from the bone seems the easiest and the best. Operation is equally indicated in acute and in chronic cases, but appears not to give results superior to the writer's method, since the mere healing of the incision is bound to occupy a fortnight of the patient's time.

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BONE METABOLISM: ITS PRINCIPLES AND ITS RELATIONS TO ORTHOPAEDIC SURGERY*

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Within the past ten years there has been published on the subject of bone metabolism a vast amount of data discovered through research and by clinical observation. The study of this subject is a natural development in the field of physiological chemistry and its details and minutiae are outside the knowledge and beyond the comprehension of the average orthopaedic surgeon. However, the clinician who treats diseases of bone must have a clear, if simplified, understanding of normal and of pathological bone metabolism, as well as a definite working method of treating bone lesions which are due to its disorders. He may make use of the facts which emanate from the laboratories of physics and chemistry, without pretending to the exact knowledge of the scientists who discovered them.

While much progress has been made in this particular branch of medical science, there are yet many statements as to facts and to their proper interpretation which are under dispute. The authors of this paper, which is written for the practical guidance of the orthopaedic surgeon, do not attempt to present this subject in detail nor to discuss controversial matters, but to state the principles of bone metabolism which are generally accepted and to demonstrate that certain methods of treatment are logical and effective.

NORMAL METABOLISM OF BONE

Bones are not inert substances. At all times they are physiologically active and particularly so during the period of growth. They are highly sensitive to local conditions, such as injury and infection, that may affect their normal blood supply and nutrition, and they react promptly to many conditions, such as malnutrition and anaemia, that affect the general metabolism of the body. The substances that constitute bone must not be understood to be fixed, but to be in a constant flux, as are the substances of all living tissues.

An adequate supply of calcium, phosphorus, magnesium, and other elements is necessary for normal metabolism of bone. These elements are brought to the bones by the blood serum which may be viewed as a saturated solution of calcium and phosphorus in a balanced ratio of 10 units of the former to 4 of the latter.

Normal plasma calcium concentration depends primarily on adequate supply of calcium in the food, on the pH of the intestinal contents, on the presence of phosphorus and magnesium, and on an adequate supply of

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vitamin D. If there be a paucity of the last in the food, it may be compensated by ultra-violet radiation of the body, either natural or artificial.

Calcium is absorbed from the intestinal canal as soluble phosphates and other compounds. The optimal absorption is attained by a dietary ratio of approximately three parts of calcium to five parts of phosphorus, as an excess of either element leads to the formation of insoluble compounds which are thrown off in the faeces.

An acidity of the intestinal contents aids in this absorption.

Vitamin D may aid in the absorption even in the presence of an imbalanced diet and in the absence of intestinal acidity. This substance is found in animal fats—such as cod-liver oil, butter, and milk—in eggs, in green vegetables, etc. It is synthesized in the laboratory from ergosterol and in the body from cholesterol by the action of the ultra-violet rays.

The maintenance of normal concentration of calcium and phosphorus in the blood is essential to the vital activity of all structures of the body. For instance, its relation to muscle tone and nerve irritability is well exemplified in tetany.

The level of concentration is controlled by vitamin D and by the secretions of the ductless glands, particularly of the parathyroid, although in a quite dissimilar manner. However, the solubility of calcium and phosphorus is associated with the presence of magnesium.

Vitamin D, when insufficiently opposed by parathormone, tends to raise the blood phosphorus and the blood calcium. Parathormone insufficiently opposed by vitamin D lowers the blood phosphorus and raises the blood calcium. Each exerts an inhibiting action on the other, and by their combined activity they maintain a normal blood concentration of calcium and phosphorus.

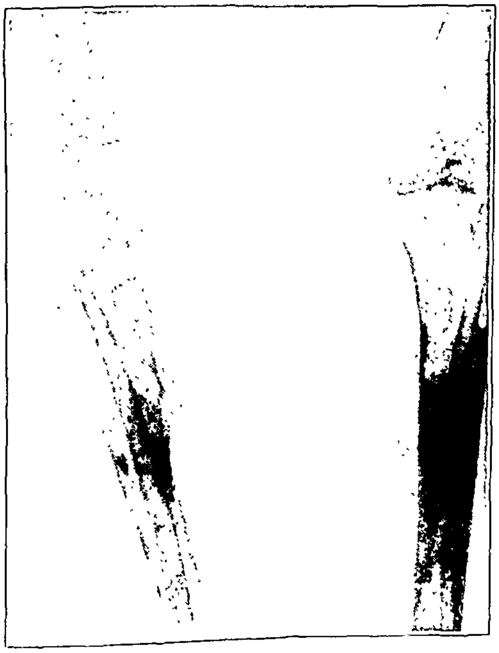


Fig. 1

Case C. P. Osteitis fibrosa cystica. Roentgenogram of tibiae, April 22, 1932.

The local factors which influence bone metabolism are: (1) the hydrogen-ion concentration and the carbon-dioxide tension of the plasma; (2) the presence of substances which may influence the solubility of calcium phosphate, such as proteins and the salts of magnesium; and (3) phosphatase and possibly other as yet unrecognized enzymes. These local factors may be activated or altered by conditions which affect the local blood supply, such as bone injury and infections and general toxaemias.

Phosphatase, an important local factor, is an enzyme which causes hydrolysis of hexose phosphate, with the liberation of phosphorus. It is

found in bone, blood serum, the kidneys, the intestines, and other tissues. It acts best in an alkaline medium and possibly in the presence of a co-enzyme or of an activator such as magnesium. It is thought to be synthesized by the cartilage cells in growing bone and by the osteoblasts. The amount found normally in the blood serum is from 1.5 to 4 units per 100 cubic centimeters in adults and from 5 to 12 units in children.

There is usually an abnormal increase in the blood phosphatase in certain bone diseases—notably rickets, osteitis deformans, and osteitis cystica fibrosa—but it is also increased in certain diseases of the liver with jaundice. The significance of these facts is not clearly understood.

DISEASES OF BONE CHARACTERIZED BY DISTURBANCE OF CALCIUM AND PHOSPHORUS METABOLISM

Generalized Osteitis Fibrosa Cystica, Recklinghausen's Disease

This symptom-complex is characterized by a high-calcium, a low-phosphorus, and a high-phosphatase content of the blood serum. The intake-output calcium and phosphorus balance is negative,—*i.e.*, the output is greater than the intake. Normal excretion of calcium occurs through the lower bowel and through the kidneys in a relation of approximately nine parts through the former to one part through the latter. The increased loss which occurs in Recklinghausen's disease takes place largely through the kidneys, so that the above ratio is greatly reduced and may even be reversed. If the kidney function becomes impaired, there is a compensatory increase in the excretion by the bowel.

FIG. 2

Case C. P. Roentgenogram of tibiae, June 10, 1932. Note increased calcification, especially in the cystic areas. Patient on a high-calcium, high-phosphorus, and high-vitamin-D diet.

FIG. 3

Case C. P. Roentgenogram of tibiae, February 14, 1934. Note that there is practically complete calcification of the cystic areas. Normal areas also show increased deposition of the bone salts.

The rapid loss of minerals from the body tends to bring about a ge eralized bone decalcification, or osteoporosis. Spontaneous fractures a frequent in advanced cases.

In another clinical type, the classical one, the demineralization bone is accompanied by the formation of numerous cysts and giant-c tumors. These must not be confused with the solitary multilocular bo cysts and the giant-cell tumors sometimes found in bones and in no w related to Recklinghausen's disease. The former can be readily disti guished from the latter by their multiplicity, by their different histologic formation as seen by the microscope, by their different location in t bones, and by the fact that they are associated with the generalized bo resorption and the typical blood changes of Recklinghausen's disease.

In a third type of this disease, called the metastatic type, the sym toms which have been described are associated with calcium deposition the kidneys and in other soft tissues. This type is not readily disti guished from so called renal rickets. These three clinical forms probab represent only different stages and phases of this disease.

Other symptoms which characterize generalized osteitis fibrosa cystic are bone and joint pains, a decreased response of the neuromuscular sy tem to stimuli, with muscular weakness at times very marked, gastro-inte tinal disturbances, polyuria and polydipsia, loss of weight, and anaemia

It is now generally accepted that this symptom-complex results fro the hypersecretion of one or more of the parathyroid glands. This vie is based on clinical observation and on an enormous amount of researc work. More than 100 parathyroidectomies have been performed for th relief of the symptoms of this disease entity since Mandl in 1926 did th first one. Improvement in the patient's condition, often striking and a most immediate, usually follows the operation. The blood picture o Recklinghausen's disease has been reproduced in animals by injections o the parathyroid hormone. These and other studies have also helped t clarify the entire subject of calcium metabolism. Finally, Jaffe, Bod ansky, Blair, and others, by injections of parathormone into susceptibl animals, have produced histological lesions in the bones that are identica in many respects with those seen in Recklinghausen's disease.

THE MODUS OPERANDI

The physiochemical method by which parathormone regulates cal cium and phosphorus metabolism is not entirely understood. Certai facts, however, have been definitely established.

Hyperparathyroidism

There is an increased output of urine and of the electrolytes of sodium, chlorine, etc., which it contains. Accompanying this diuresis, there is an increase in the excretion of soluble calcium phosphates through the kid- neys. One reason for this is the fact that a larger quantity of urine with its contained electrolytes naturally carries with it in solution a greater

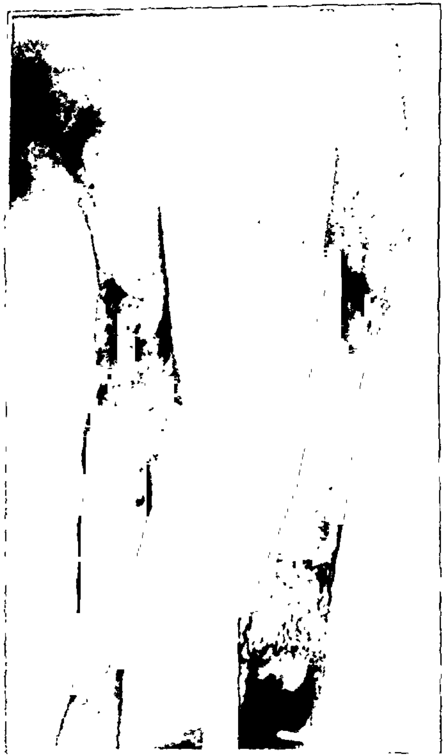


FIG. 4-A FIG. 4-B

Fig. 4-A: Case C. P. Appearance of right femur on *admission, April 22, 1932.*

Fig. 4-B: Case C. P. Right femur, February 24, 1934. Patient on high-calcium, high-phosphorus, and high-vitamin-D diet. Note improvement in calcification, especially in the appearance of the cyst wall.

FIG. 5

Case C. P. April 22, 1933. Giant-cell *tumor of the right femur.*

FIG. 6

Case C. P. A later view of giant-cell tumor shown in Fig. 5.

quantity of salts. Furthermore, there appears to be an increased solubility of calcium and phosphorus both in the body fluids and in the urine owing to a slight increase in magnesium concentration and to a moderate shift of the pH to the acid side.

Parathormone increases solubility of calcium phosphate in the blood. Its first action appears to be a phosphate diuresis, causing a reduction of inorganic phosphorus in the blood. This, in turn, increases the activity of the calcions in the blood and then there is an actual increase in total calcium concentration. Bone salts flow into the blood because of a change in the equilibrium between solids and fluids. Excess of ions (soluble electrolytes) is probably the chief factor in the increased solubility of the blood and of the urine. In other words, an increase of water, magnesium, sodium, and chlorine in the circulating fluids about the bones causes a shift of calcium phosphate from the bones to the fluids.

Following decalcification, or halisteresis, osteoclasts proliferate and act as phagocytes on decalcified bone matrix. Fibrosis and the formation of giant-cell tumors occur during the process.

FIG. 7-A FIG. 7-B

Fig. 7-A: Case C. P. October 1932. Patient on high-calcium, high-phosphorus, and high-vitamin-D diet. Note shell in large giant-cell tumor, also evidence of increased general calcification.

Fig. 7-B: Case C. P. January 31, 1933. Patient on high-calcium and high-phosphorus diet. Vitamin D has been dropped since date of Fig. 7-A. Note loss of shell of giant-cell tumor, but there is still a general increase in calcification.

Hypoparathyroidism

There is an inability to excrete excess phosphorus by urine. The output of urine is decreased. The phosphorus unites with cations of calcium, strontium, magnesium, etc., to make insoluble phosphates which are excreted through the colon. The calcium in the blood, therefore, is lowered, while the phosphorus is high. Symptoms of tetany may appear. Various forms of treatment may be used to control this:

1. Administration of sodium chloride causes diuresis and increased solubility of calcium phosphate in the

urine by electrolytic action and an increased amount of water.

2. Ingestion of an increased amount of calcium speeds up the elimination of phosphorus in the faeces and allows a larger remainder of calcium for the body.

3. Injection of parathormone increases the amount of urine and the solubility of calcium and phosphorus.

4. Administration of magnesium may also control the manifestations of tetany.

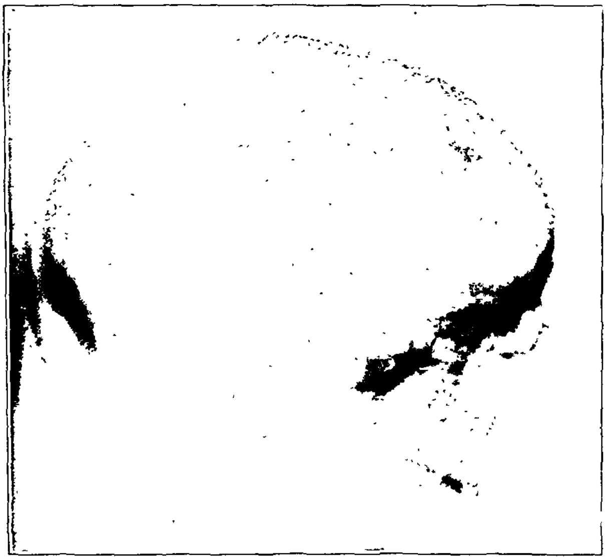


FIG. 8
Case C. P.: Roentgenogram of skull, April 23, 1932.

FIG. 9
Case C. P.: Roentgenogram of skull, April 3, 1933.

Renal Rickets

This condition closely resembles generalized osteitis fibrosa. It is believed that primary damage to the kidneys is the first and basic factor in the development of this disease. Renal elimination becomes impaired. There is a retention of phosphorus in the body, although a portion of the excess is excreted through the lower bowel in the form of insoluble calcium phosphates. There takes place a physiological stimulation of the parathyroid glands to aid in the elimination of phosphorus. Hyperplasia of these glands follows. General decalcification of bones occurs. This decalcification has been attributed to various causes: (1) persistent chronic acidosis; (2) retention of electrolytes and non-protein nitrogen which increase the solubility of calcium phosphate; (3) overactivity of the parathyroid glands; and (4) loss of calcium by the colon in the form of insoluble phosphates. Calcification occurs in the kidneys, due possibly

to a change in the solubility of calcium in the urine and to an alteration in the damaged kidney tissues, which favors local deposit.

It is apparent therefore, that when this complete picture of hyperparathyroidism and kidney calcification is developed, a differentiation of the two diseases may be made only by discovering the history of renal damage that preceded the skeletal changes. That the retention of phosphorus in the body may cause hyperplasia of the parathyroid glands is supported by the experimental evidence that such hyperplasia may be produced by a diet which is excessive in phosphorus.

True or primary hyperparathyroidism differs, therefore, from renal rickets in that a true secreting parathyroid adenoma is the cause of the former, while in the latter the parathyroid hyperplasia is a secondary development due to kidney damage. It may be possible that when this hyperplasia has become established it passes the limits of a physiological process and becomes pathological.

TREATMENT

Parathyroidectomy

If in true hyperparathyroidism the primary fault is an excessive hormone secretion from the parathyroid glands due to a secreting adenoma, it would appear logical to diminish the secretion by removing the adenoma. Many cases have undoubtedly been improved by parathyroidectomy, particularly those in which a true adenoma has been found and removed. Some cases have not been improved by operation, probably because the adenoma was not found and only normal parathyroid glands were removed. The danger of tetany must be borne in mind and guarded against.

Irradiation

This method of treatment may accomplish the same results as are obtained by operation.

Diet

By diet alone the symptoms of hyperparathyroidism may be controlled. Since there has been an enormous loss of both calcium and phosphorus from the body, it is primarily essential that they be replaced through the diet. It is evident that this replacement is necessary even though the disease has been controlled by parathyroidectomy. When it has not been so controlled, it is essential to give sufficient quantities, not only to replace the loss that has already occurred, but to compensate for the continued loss that occurs through the overactivity of the parathyroids. This is accomplished by giving foods such as milk, cheese, meats (including fish), which have a high content of calcium and phosphorus, and, if necessary, by adding to the diet calcium and phosphorus salts. The calcium may be administered as a chloride, carbonate, lactate, or gluconate; the phosphorus as the monosodium or the disodium phosphate. However, dicalcium phosphate, which combines both elements in one compound, answers the purpose and preserves the normal ratio of calcium

and phosphorus which should at all times be maintained in diet. They must be given in sufficient quantities—*e.g.*, two to seven grams of dicalcium phosphate—to produce and to maintain a positive intake-output balance—*i.e.*, the intake through the food should exceed the output through the urine and faeces by approximately one gram of each per day. If laboratory studies of this balance cannot be made, an approximate index of a positive balance will be found in increasing bone calcification, as shown in roentgenograms, and in an approach of the blood chemistry toward the normal. Increased bone calcification has been noted in five weeks after the beginning of treatment.

The administration of vitamin D in large amounts is essential. Thirty to sixty drops of 250 D viosterol (10,000 D per gram) is adequate, the amount given being dependent on the severity of the symptoms of the disease. The vitamin D probably is antagonistic to the action of parathormone; it aids in deposition of calcium and phosphorus in the bones; and it aids in absorption from the intestinal tract.

Many writers have spoken of the danger of producing metastatic calcification if a high-calcium, high-phosphorous, and high-vitamin-D intake is pushed. In a case treated by the authors, which is reported in full at the close of this paper, a high intake has been maintained for four years with a remarkable degree of bone healing and without evidence of any kidney damage. In fact, the only period during which the patient has had any kidney dysfunction occurred at a time about two years ago when, because of an automobile accident, she was admitted to another hospital for three months. There she was given a diet high in phosphorus and low in calcium and in vitamin D. When she returned to our care at the end of this time she showed evidence of kidney damage and bone decalcification. Her balanced diet was restored; the kidney function returned to normal;

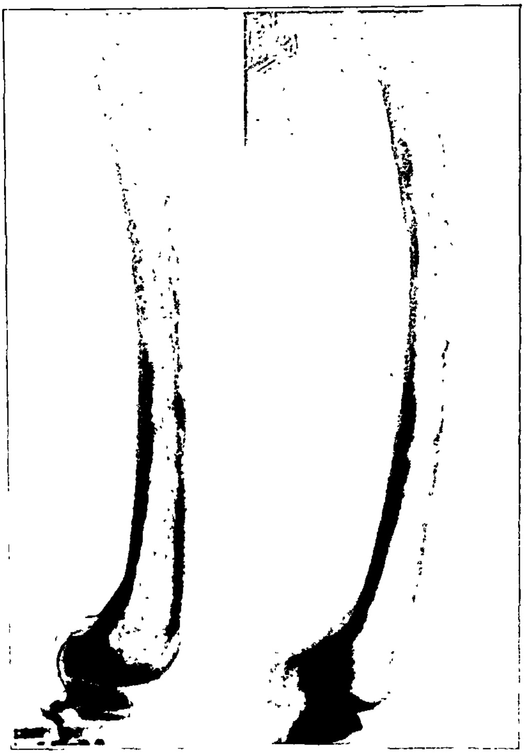


FIG. 10-A FIG. 10-B

Fig. 10-A: Paget's disease, showing femur before magnesium therapy.

Fig. 10-B: Same case as shown in Fig. 10-A after six weeks of magnesium therapy. Note decalcification.

bone calcification increased; and she has been quite well since that time.

The entire subject of nephrolithiasis is not yet fully understood or entirely settled. In primary hyperparathyroidism there is an excessive excretion of calcium and of phosphorus through the kidneys due, as already stated, to the fact that the amount of urine and the solubility of calcium and phosphorus are increased. An increased solubility would reasonably be expected to lessen the danger of stone formation even if associated with kidney hyperfunction. If the solubility is lessened by insufficient intake of water, of sodium chloride, and of other substances which have direct bearing on solubility, precipitation of calcium phosphate may occur. In renal rickets the kidneys have at some previous time suffered damage and calcification is common, not because of hyperfunction, but because of dysfunction. There is parathyroid hyperplasia which tends to increase the solubility of calcium in the body fluids, as in true or primary hyperparathyroidism, but, in spite of this, kidney calcification occurs. It would appear, therefore, that kidney damage is an important factor in the production of stone. Furthermore, nephrolithiasis occurs in individuals who are not suffering, so far as is known, from any chronic bone resorptive lesions and who have no disturbance of their calcium metabolism.

Therefore, does it not seem reasonable that, if in primary Recklinghausen's disease we increase the intake of calcium and of phosphorus

FIG. 11

Paget's disease, showing pelvis. Note occlusion of the joint cleft and also the exostosis at the lower border of the left acetabulum.

to balance or even slightly to exceed the output, and if at the same time we give vitamin D which aids in bone calcification, the first deposition of these elements should be in those structures (the bones) where such a deposit normally occurs and which are calcium hungry? Stated in another way, if vitamin D, contrary to parathormone, lessens the solubility of calcium salts in the body fluids, is it not reasonable to suppose that an excess of calcium in the blood serum will be deposited in the normal storehouse in the bones instead of in the soft tissues? Furthermore, even if a part of this excess cannot be so assimilated, why should not the kidneys and the lower bowel be able to take care of it as they do in a normal individual who has ingested more calcium than the body can use?

In *renal rickets*, in which there is a primary retention of phosphorus and a secondary loss of calcium, it would seem reasonable to raise the calcium intake and to keep the phosphorus intake low. This plan of treatment is further justified by the experimental observation that a low-calcium diet may produce a condition closely resembling renal rickets. Vitamin D should be given in moderate doses to assist in recalcification and to antagonize the hypersecretion of parathormone.

There are some authorities who believe that parathyroidectomy is indicated where there is kidney damage, so that a smaller intake of

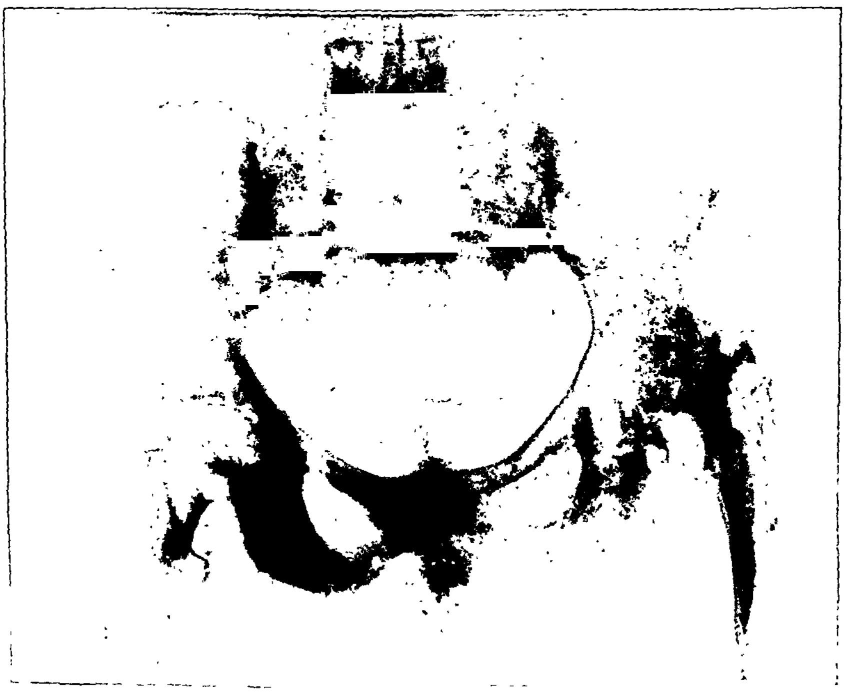


Fig. 12

Same case as shown in Fig. 11 after six weeks of magnesium therapy. Note decalcification and the disappearance of the exostosis and the reappearance of the joint cleft.

calcium, of phosphorus, and of vitamin D would serve to keep the patient in balance. Surgical operation is certainly a reasonable procedure if the parathyroid hyperplasia exceeds the physiological limits and has become pathological.

Osteogenesis imperfecta is probably due to a congenital defect and is not associated with parathyroid dysfunction. One case has been under the observation of the authors for six years. This patient has been treated with thymus gland, with thymus extract plus high-calcium, high-phosphorus, and high-vitamin-D diet, and with thymus extract alone at different periods. Also, careful studies of her blood chemistry, of her intake and output, and of the roentgenographic appearance of her skeleton have been made. No marked change and no lasting improvement have resulted from any of these means of treatment. Possibly the fact that this disease appears to undergo phases of progression and recession accounts for apparent improvement under various methods of treatment, which has been followed by a relapse.

Rickets and osteomalacia of the low-phosphorus type, which is the ordinary form, are caused by a reduction in the lime salts, but with a relatively low-phosphorus, high-calcium, and low-vitamin-D intake. It is apparent that the treatment consists merely in supplying vitamin D and in giving adequate amounts of phosphorus and of calcium in balanced normal ratio. It can be seen that, since the bone change is produced on a diet relatively low in phosphorus, there is no call for parathormone hypersecretion, and, therefore, one would not expect to find hyperplastic parathyroids.

Paget's disease is associated with certain metabolic changes. It is characterized by definite well known roentgenographic changes and deformities of bones and by certain clinical manifestations, such as bone pains, local tenderness and elevation of temperature, particularly noted in the tibia, joint stiffness, and myotonia.

The blood chemistry is normal except for a high-phosphatase content of 12 units and upward. Balance study indicates a moderate retention of calcium and of phosphorus, which may vary in degree, and often a retention of magnesium and a loss of sulphur. There is no evidence to connect this disease with disorders of the parathyroid.

The following treatment, adapted from Dr. Laslo Kajdi's treatment of juvenile hyperostosis, has been found by the authors, in collaboration with Dr. Kajdi and Dr. Corson White, to be beneficial. It consists in the use of a diet low in calcium, low in phosphorus, and high in magnesium. The last is given as magnesium carbonate in dosages of from four to ten grams per day. Each month a study of the blood phosphatase and magnesium is made; of the former to check the progress of the patient, and of the latter to avoid the danger of magnesium toxicity which might occur if kidney function became impaired for any reason. Every six months a balance study is made.

The efficiency of the treatment is indicated by a lessening of calcium

and of phosphorus retention, by a decrease in the blood phosphatase, by a decrease in the density and in the diameter of the long bones, by a subsidence or disappearance of such symptoms as pain, local tenderness and heat, stiffness, and fatigue, and at times by a definite improvement in kidney function. It seems probable that the use of magnesium exerts a favorable influence in Paget's disease, because it increases the solubility of calcium and of phosphorus, as stated in a preceding paragraph, and because it acts as a vasodilator. In chronic hypertrophic arthritis the use of magnesium was suggested by Dr. Mitchell Rubin and has been carried out by one of the authors (I. S.), in collaboration with Dr. Corson White, with what appear to be favorable results in selected cases.

A calcifying diet might be found useful in bone lesions which are not essentially metabolic, such as tuberculosis, widespread myeloma, major fractures, etc.

The authors have been making observations as to the usefulness of such a diet in tuberculosis of bone, but they are unable as yet to publish any definite conclusions.

In atrophic arthritis with generalized bone atrophy it may be found that the employment of the principles of calcification will aid in restoration of normal metabolism of the bones. This would appear to be a fruitful field for observation and research.

Heretofore, attention has been focussed largely on normal calcification and calcifying regimens. It is evident, however, that, in enumerating the principles of calcification, the causes of decalcification are obvious.

Decalcification may be caused: (1) by an inadequate dietary and vitamin intake, low-calcium and high-phosphorus or low-phosphorus and high-calcium, with low-vitamin-D in both; (2) by hypersecretion of parathormone; (3) by the administration of such elements as magnesium and strontium; and, (4) by physiological processes attendant upon prolonged fixation of an extremity in a plaster cast, upon paralysis, and upon muscle atrophies, etc.

The work of Nachlas and Shelling in producing softening of bones for the purpose of correcting rachitic deformities is well known. For this purpose they have employed strontium, which has a higher decalcifying power than magnesium.

In considering this question of diet therapy, it should be borne in mind that the following foods have a high-calcium and high-phosphorus content: milk, cheese, eggs, meat, sea food, peas, beans, nuts, plums, peaches, prunes, and apricots. They are to be given in generous quantities in a calcifying diet and are to be omitted in a decalcifying diet. The addition of dicalcium phosphate and viosterol D, as previously mentioned, is essential for production of rapid calcification.

CASE REPORT

C. P., a white female, aged thirty-one years, was admitted to the Orthopaedic Hospital on April 21, 1932, on the Service of Dr. A. Bruce Gill.

The family history was negative.

The patient had been well until the age of twenty. She had then married and had immediately become pregnant. On March 14, 1920, she had noticed a small growth on the alveolar margin of the mandible. Roentgenographic diagnosis was as follows: "A large area of bone absorption between the first bicuspid and second molar, thinning of the mandible, sarcoma of the mandible." At operation in a hospital in Hartford, Connecticut, a giant-cell tumor was removed. Thirteen x-ray treatments were given after the operation. The pregnancy went to term, and the baby died in convulsions a few days after birth.

In 1927 the patient had begun to suffer from severe indigestion, with gastric pain and vomiting. Pain in the legs and in the arms had developed, and later in the same year a gastro-enterostomy had been performed in a Philadelphia hospital with relief from indigestion. However, pain in the extremities had continued and had increased, and the patient had lost weight.

In September 1927 a tumor had developed on the maxilla and another on the left malar bone. The latter tumor had been removed in August 1928. In September 1928, when struck by a revolving door, the patient had suffered a fracture of the left femur. She had been treated in a Philadelphia hospital for two months and then had been sent home with non-union of the fracture. She did not walk again until after treatment in the Orthopaedic Hospital in 1932.

The patient had next noticed a tumor developing in the left tibia. In January 1929 she had fractured her right femur in attempting to change her position in bed.

On March 20, 1930, two parathyroid glands had been removed from the left side in the Jefferson Hospital. Histological examination of the specimen had showed normal parathyroid tissue and a small nodule of thyroid gland. At this time the blood calcium was twelve and seven-tenths milligrams and the phosphorus was one and seven-tenths milligrams. There was noted local pain and heat in the tibial tumor.

On September 1, 1930, an operation had been performed for an abscess on the broad ligament. In January 1931 the patient had been placed on a high-calcium diet with cod-liver oil. She had been discharged from Jefferson Hospital on May 6, 1931, feeling more comfortable, but showing no other improvement.

On admission to the Orthopaedic Hospital in April 1932, the laboratory report was as follows:

Red blood cells—3,370,000
Hemoglobin—60 per cent.
Color index—0.9
White blood cells—5,900
Calcium—14 milligrams per 100 cubic centimeters of blood
Phosphorus—3.2 milligrams per 100 cubic centimeters of blood

The urinalysis showed specific gravity of 1.010 with alkaline reaction. Albumin, red blood cells, and pus cells were present, but Bence-Jones bodies were absent. The phenolsulphonphthalein test gave 55 per cent. in three hours.

The patient had not walked for almost four years. There was marked muscular weakness and she was unable to move her legs. Numerous tumors were present, particularly one of the left tibia and a massive one of the upper portion of the right femur. The fractures had healed, but she complained of pain in the legs.

On April 28, 1932, she was placed on a high-calcium, high-phosphorus, and high-viosterol diet,—six to seven grams of calcium and phosphorus a day, and increasing doses of viosterol up to sixty drops per day. On June 10, 1932, there was definite roentgenographic evidence of increased calcification of the bones.

On June 13, 1932, two parathyroid glands were removed from the right side of the neck. Microscopic examination of these glands showed considerable fatty infiltration, with evidence of oxyphilic cells, but with comparatively few principal cells.

On June 20, 1932, the blood calcium was eight and eight-tenths milligrams and the

phosphorus was three and fifteen-hundredths milligrams. The patient felt stronger and was free from pain. She was allowed up in a wheel chair for the first time.

The diet was continued with some variations from time to time in ratio of calcium and phosphorus.

On August 24, 1932, the patient was fitted with braces and was able to stand up. She was discharged from the hospital on October 9, 1932, walking with braces and crutches.

In November 1932, the viosterol was dropped from the diet and, by January 1933, the patient had suffered some decalcification. The viosterol was then restored to her diet, and by March she had regained what had been lost. In February 1933, she was able to discontinue the use of the braces and to do her housework for the first time in more than five years. During this period of her treatment her intake-output balance studies indicated an average daily retention of more than two grams of calcium.

In May 1933, an attempt was made to lower the intake of calcium, phosphorus, and vitamin D, but it was found that she could not be kept in balance unless the viosterol 250 D was maintained at sixty drops and the calcium and phosphorus at six grams a day.

In July 1934, the patient had an automobile accident and suffered fractures of both bones of the right forearm, of the right femoral neck, of three ribs, and of the right humerus. She was admitted to another hospital for three months, where she was kept on an incorrect diet of low-calcium, high-phosphorus, and high-viosterol intake. The result was decalcification and kidney damage. The latter was indicated by a drop in the phenolsulphonephthalein from 70 per cent. to 30 per cent., by an increase in the non-protein nitrogen to above 60 milligrams per 100 cubic centimeters, and by the marked presence of albumin and of hyaline and granular casts. The patient was readmitted to the Orthopaedic Hospital. The fractures were ununited; the blood calcium was high and the blood phosphorus low, and the patient was in negative balance. Her diet was corrected by putting her on a high-calcium, high-phosphorus, and high-vitamin-D intake. The ununited fractures healed and she again began to have increasing calcification of bone. Since that time she has been well. Her blood chemistry is normal. Her blood phosphatase was originally 18 to 20, and is now 1.5 to 2.5.*

This very interesting and instructive case demonstrates numerous facts mentioned in this paper. If we assume that this patient had a primary parathyroid adenoma, she still has it. While three parathyroid glands have been removed, they were definitely atrophic in type, and their removal did not control her condition.

Definite control and improvement have been secured only through a high-calcium, high-phosphorus, and high-vitamin-D diet. The blood chemistry is now normal and the blood phosphatase has fallen to normal levels. The balance studies are positive, showing an average retention of at least two grams a day. The bones have calcified and pain has ceased. Muscular strength has improved and the patient can now walk without braces and crutches.

Her only kidney dysfunction developed during a period of incorrect diet and disappeared as soon as the balance of phosphorus and calcium intake was restored to the normal ratio of five to three.

The authors have offered this paper with the object of clarifying this subject of bone metabolism in the minds of many orthopaedic surgeons,

* We are indebted to Dr. Corson White for the laboratory work done in this case and for her collaboration in carrying out the treatment, and to Dr. Ralph Bromer for his careful roentgenographic studies.

and of stimulating their interest in bone diseases characterized by a disturbance of bone metabolism. A number of promising fields of research and of clinical observation seem to be opening up before us. We must be careful, however, not to apply methods of calcification and decalcification indiscriminately and thoughtlessly, but only after careful observation and sound reasoning. Final conclusions must be reached slowly after oft repeated experiments, and as a result of accumulated knowledge. It must be borne in mind that this entire branch of medical science is still in its infancy and that its basic facts and principles are discovered by the physiological chemist, but that the orthopaedic surgeon may assist in the development of our knowledge by careful clinical observations.

The authors are particularly indebted to the work and writings of Dr. David Shelling and they recommend to the reader his recent book.[1]

1. Shelling, David H.: The Parathyroids in Health and in Disease. St. Louis, C. V. Mosby Co., 1935.

METABOLIC STUDIES IN OSTEOCHONDRITIS OF THE CAPITAL FEMORAL EPIPHYSIS

BY LYMAN A. CAVANAUGH, M.D., AND E. KOST SHELTON, M.D., SANTA BARBARA, CALIFORNIA, AND ROSS SUTHERLAND, M.D., LOS ANGELES, CALIFORNIA

Although recognized in comparatively recent years, nevertheless osteochondritis of the capital femoral epiphysis has an extensive literature. The disease was originally described by Legg in 1909 as "an obscure affection of the hip joint", and independently by Calvé and Perthes in 1910. However, it was Perthes (1913) who first gave a clear-cut description of the clinical course, the roentgenographic findings, and the pathology. The accumulated literature consists principally of discussions of the possible etiology and pathology with certain suggested refinements in treatment. Certainly a step in advance has been the recognition that osteochondritis of all growth or epiphyseal centers is probably one and the same disorder. There is as yet, however, no clear-cut concept of the disease, of its etiology, or of its underlying pathology.

Perthes' classical description of the pathology as exemplified by a single case in 1913 has not been materially changed. Numerous other studies of tissue removed from the epiphysis and the diaphysis during the active course of the disease have been reported. Most of these investigators have not differed materially from Perthes' original description. The variations as regards the description of tissue examined will have to be considered in the light of a series of well-controlled observations before a clear concept of the pathology will be possible.

The etiology of this disease has been a subject of controversy since the original work of Legg, Calvé, and Perthes. A considerable number of causative factors have been suggested. These include infection, syphilis, congenital anomaly, osteomalacia and rickets, endocrine imbalance, undiagnosed congenital dislocation of the hip, alterations in calcium and phosphorous metabolism, trauma or trauma with secondary circulatory disturbances, and arrested or inferior development in the epiphysis affected. The last will receive further consideration.

Most recent investigators are agreed that osteochondritis of all epiphyseal centers is one and the same process with a common etiology. If this is true, there is very little reason to believe that any one of the aforementioned etiological factors is the sole explanation of a picture as typical as that of osteochondritis. Overton suggests insufficient nutrition of the epiphysis as the etiological factor. This seems to be approaching a more tenable concept. The question immediately arises, however, as to what factor or factors are responsible for the disturbed nutrition.

In regard to arrested or inferior development of the epiphysis affected, Gonzales-Aquilar cites Lawen and Seemen as having described several forms of pathological chondral ossification in conjunction with alterations

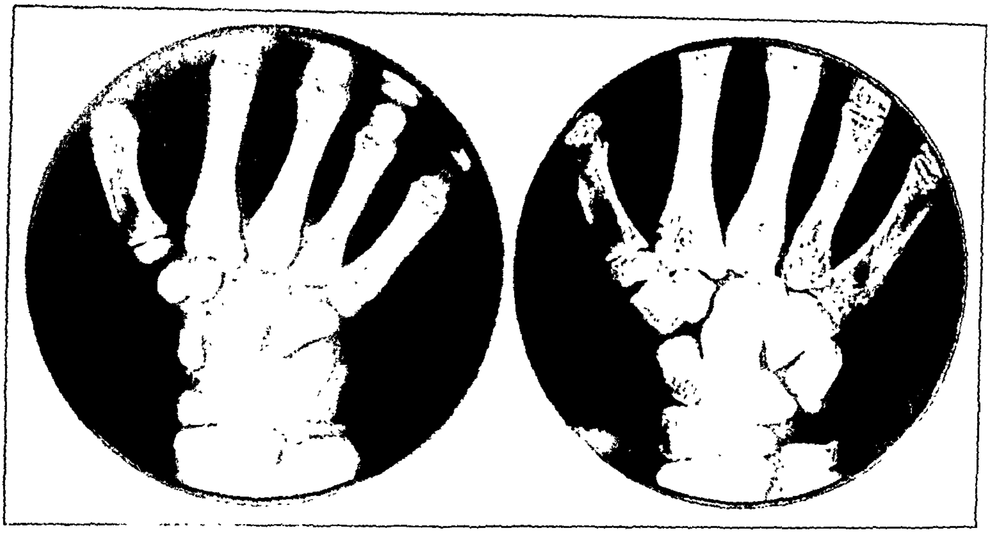
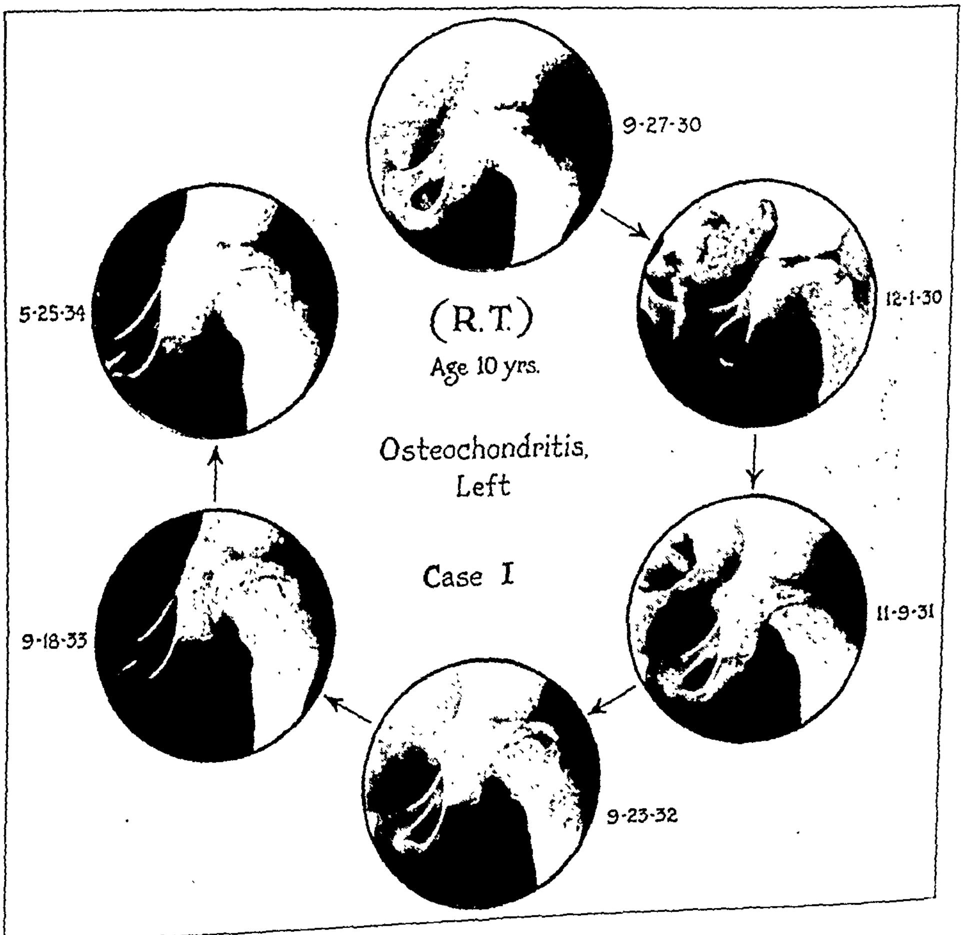


FIG. 1
Case 1. R. T. *Patient's wrist (left) compared to approximate normal for age.*

in function of the thyroid. Nagasaka, reporting on the histological study of eight cases, cited lateness and abnormality in endochondral ossification as consistent observations. Kehl felt that an abnormality in development, combined with trauma, was the cause. Hilgenreiner



mentioned instances where considerable retardation in development of the affected epiphysis was noted prior to the onset of osteochondritis, and he suggested this local disturbance as the cause. Apparently none of these authors has investigated the degree of ossification in other epiphyseal centers.

The purpose of this paper is to present a study of five unselected and uncomplicated cases * of osteochondritis of the capital femoral epiphysis, in all of which there is definite evidence of a metabolic deficiency.

In order to avoid repetition, the negative findings in the following cases, with a few exceptions, will be considered *en masse.* In no instance was there a history of other cases of osteochondritis in the family. Physical examination revealed nothing abnormal in the heart, lungs, or abdomen. The hemoglobin, red and white cell count, differential count, and urine were normal in each case. The blood Wassermann and the Von Pirquet tests were negative in all cases. The serum calcium and phosphorous were obtained only in Cases 1 and 3, and they were normal in both. Stool examinations were negative.

All patients received supervised physiotherapy, consisting of pool exercise regularly, to prevent disuse atrophy. Inasmuch as the Clinic offers school facilities for all orthopaedic cases in addition to the medical, surgical, and physiotherapeutic services, it can readily be seen that all patients have been under close observation.

CASE REPORTS

CASE 1. R. T., a white male, aged ten years, was admitted in September 1930. He complained of pain in the left hip and a limp of three months' duration. There had been no known trauma. Physical and roentgenographic findings were consistent with osteochondritis. Treatment for the first fifteen months consisted of a Bradford abduction-traction brace which was replaced by a cast at the end of four months. Continuous retrograde changes were noted in the epiphysis during this period.

The patient was referred to the Endocrine Clinic in December 1931. Additional interrogation brought out histories of goiter in the mother and in the maternal aunt. Further physical examination revealed a boy short in stature, moderately obese, with poor genital development, left cryptorchidism, retarded dentition, and a palpable thyroid. Roentgenographic studies of the wrist revealed an epiphyseal development equivalent to that in a child of approximately six years. Treatment from this time on consisted of the administration of one grain of thyroid daily. Progressive improvement was noted in the affected epiphysis. Both testicles were found in the scrotum at the end of six months. Weight-bearing was controlled by an abduction-traction brace for fifteen months. At the end of this period there was almost complete reconstruction of the epiphysis, and the brace was removed.

The patient remained under observation for an additional fifteen months. Check-up studies of the hip during this time revealed a comparatively normal epiphysis, with the exception of moderate flattening. There was concomitant improvement in the relation of epiphyseal development to chronological age. Thyroid medication was continued under supervision.

CASE 2. R. P., a white male, aged six years and four months, was admitted in September 1931, with a history of a limp on the left side, asthma, and frequent

* The clinical material presented represents consecutive cases seen in the Adelaide Tichenor Orthopaedic Clinic, Long Beach, California.

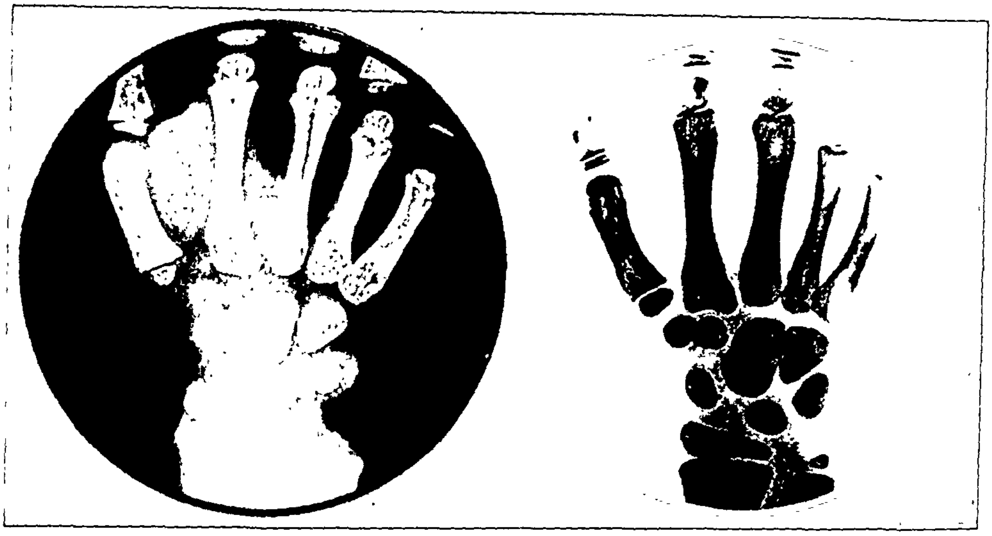


FIG. 3

Case 2. R. P. Patient's wrist (left) compared to approximate normal for age.

colds and sore throats. The onset of the limp had occurred a year previously, and the condition had been present intermittently since that time. The tonsils and adenoids had been removed four months after the onset of the symptoms, with no relief. Physical and roentgenographic findings were consistent with osteochondritis of the left capital

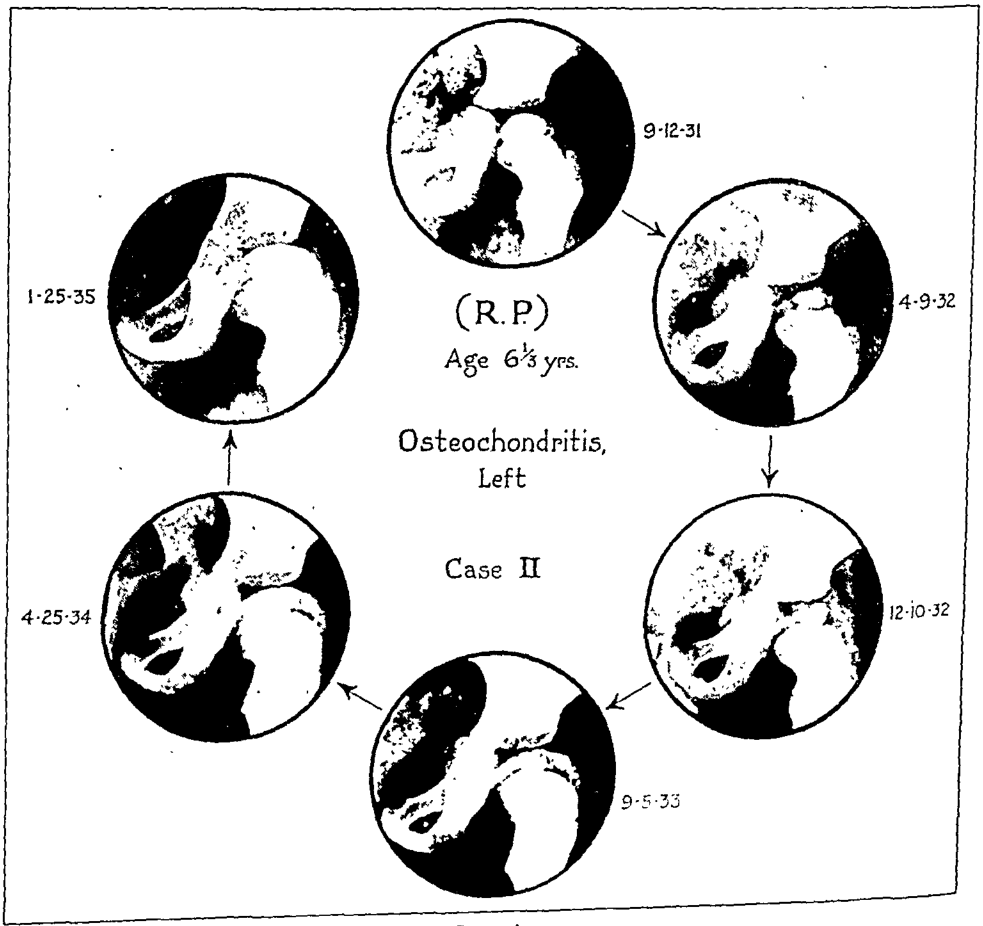


FIG. 4

femoral epiphysis. Treatment for the next nine months consisted of a Bradford abduction-traction brace. Progressive destruction in the epiphysis and in the diaphysis was noted during this period.

The patient was referred to the Endocrine Clinic in May 1932 at which time there was elicited a history of large colloid goiters in the mother, a maternal aunt, and the

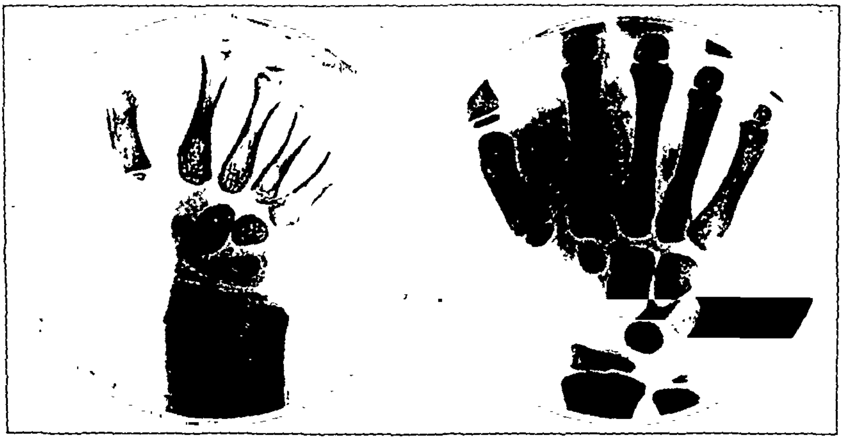


FIG. 5
Case 3. R. B. Patient's wrist (left) compared to approximate normal for age.

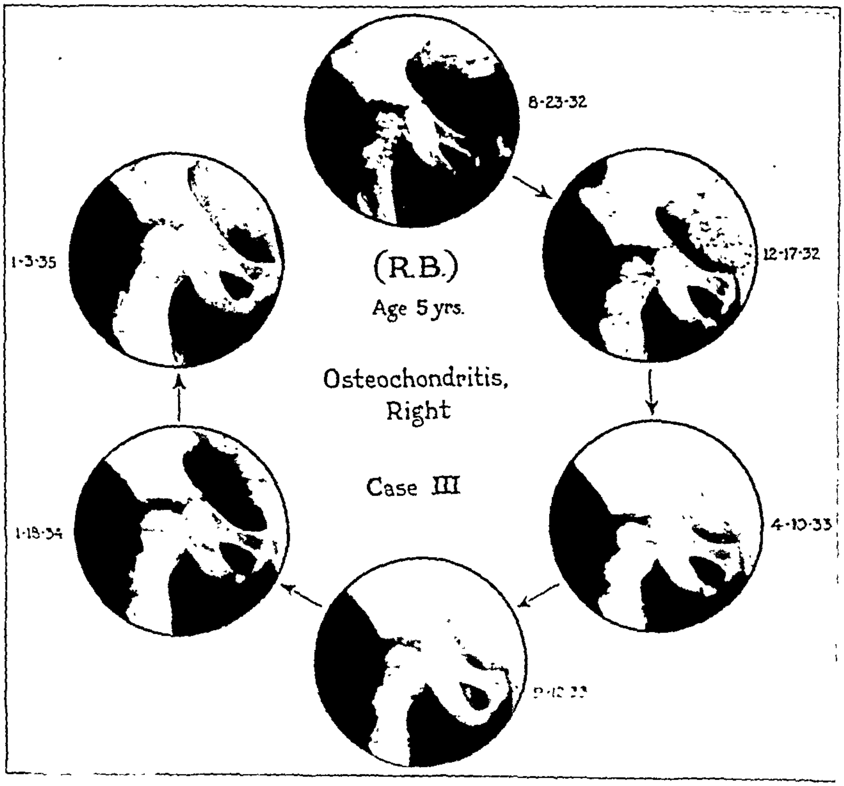


FIG. 6

grandmother and a toxic goiter in another maternal aunt. Further examination revealed left cryptorchidism and an epiphyseal development equivalent to that in a child of approximately four years. Treatment consisted of the administration of from one-half to three-quarters of a grain of thyroid daily. The patient was placed in a cast for three months; a Bradford abduction-traction brace was then applied. Both testicles were found in the scrotum at the end of three months. There was no recurrence of asthma after twelve months.

There was progressive improvement in the epiphysis during the next thirty months, and the brace was removed. There was concomitant improvement in the relation of epiphyseal development to chronological age. Thyroid medication was continued under supervision.

CASE 3. R. B., a white male, aged four years and ten months, was examined in the Endocrine Clinic in August 1932. There was a history of a limp on the right side, of three weeks' duration, and enuresis. There had been no known trauma. The family history revealed that the mother, maternal aunt, and two uncles had goiter. In addition to the physical and roentgenographic findings of osteochondritis, large cryptic tonsils and obstructive adenoids were found. Studies of the right wrist revealed an epiphyseal development corresponding to that in a child of three years.

The tonsils and adenoids were removed, and the child was kept under observation. At the end of four months definite retrograde changes were noted in the epiphysis and a Bradford abduction-traction brace was applied. One-half a grain of thyroid daily was prescribed. Enuresis did not recur after the first two months, and progressive improvement was noted in the epiphysis. At the end of twelve months complete reconstruction of the epiphysis was found, and the brace was discontinued.

The patient was kept under observation for an additional twelve months, and check-up studies revealed only normal findings. There was concomitant improvement in the relation of epiphyseal development to chronological age. The administration of thyroid was continued under supervision.

CASE 4. D. M., a white male, aged nine years, was examined in the Endocrine Clinic in June 1932. Examination showed a limp on the left side and carious teeth, and the history revealed enuresis and frequent sore throat. The onset of the limp had occurred one month previous to admission. There had been no known trauma. The family history disclosed that the mother had a large colloid goiter. In addition to the physical and roentgenographic findings of osteochondritis, examination showed very dry skin and hair, carious teeth with retarded dentition and a narrow crowded arch, large cryptic tonsils, and an epiphyseal development equivalent to that in a child of from six to seven years. Treatment consisted of the removal of the tonsils and the adenoids, the application of a Bradford abduction-traction brace, and the administration of three-fourths of a grain of thyroid daily. After two months there was no further enuresis nor progress in dental caries.

Check-up studies of the hip revealed progressive improvement in the epiphysis, and, at the end of thirty months, the brace was removed and normal weight-bearing was permitted. The patient remained under observation during an additional five months, and a comparatively normal epiphysis was found at the end of that time. There was concomitant improvement in the relation of epiphyseal development to chronological age. The administration of thyroid was continued under supervision.

CASE 5. G. R., a white female, aged six years, was examined in the Endocrine Clinic in February 1933. There was a history of a limp on the right side, abnormal behaviorisms, and enuresis. The limp had appeared following an injury three months previous to examination. The family history revealed that the mother had a palpable colloid goiter. In addition to the physical and roentgenographic findings of osteochondritis, examination disclosed dry skin and hair, malocclusion, and a palpable enlarged thyroid. Studies of the right wrist showed an epiphyseal development equivalent to that in a child of four years and six months. Due to a misunderstanding, the patient was under

observation in another clinic for the next twelve months, where she received no treatment other than occasional observation. At the end of this period she returned to the Endocrine Clinic and roentgenographic examination of the hip revealed almost complete disintegration of the capital femoral epiphysis. There was actual shortening of the right leg amounting to one and one-quarter inches. All of the other disorders were

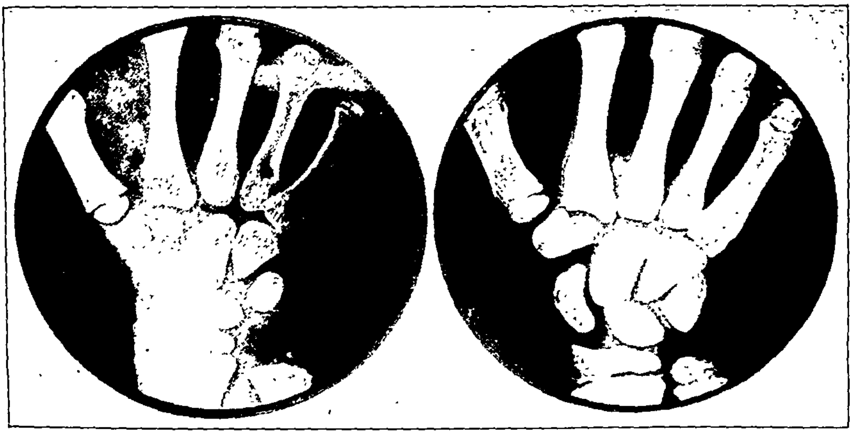


Fig. 7

Case 4. D. M. Patient's wrist (left) compared to approximate normal for age.

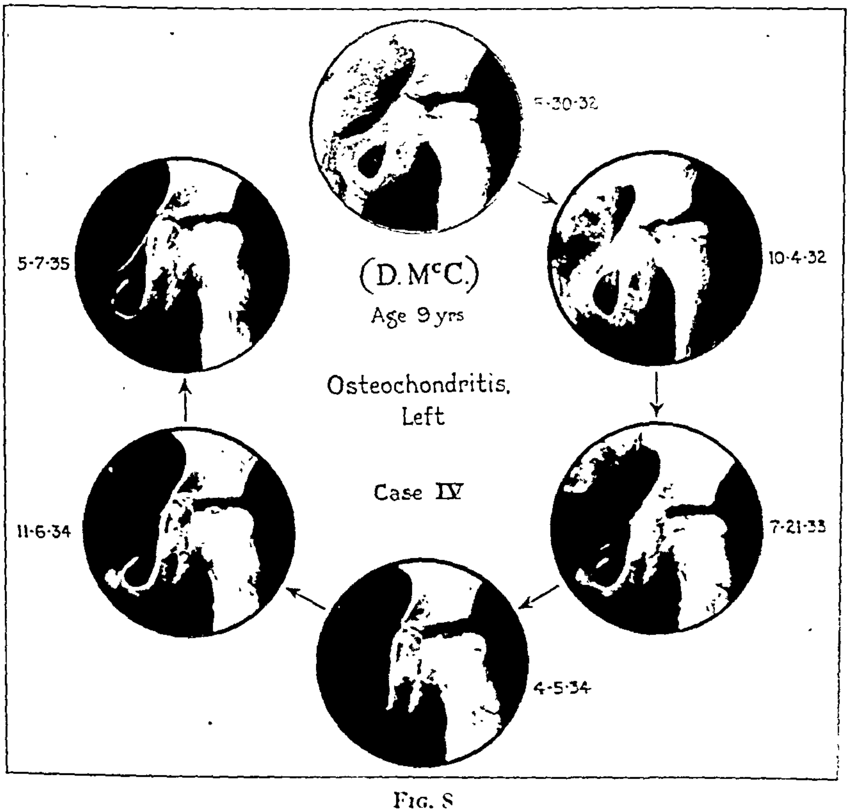


Fig. 8

still present. A Bradford abduction-traction brace was applied and half a grain of thyroid daily was prescribed. Enuresis did not recur after six weeks. Three permanent teeth erupted within two months.

At the end of six months there were no further complaints of abnormal behaviorisms. Progressive improvement was noted in the epiphysis with complete union of all fragments and a smooth articular surface at the end of twenty-two months. The brace was removed. Concomitant improvement was noted in the relation of epiphyseal development to chronological age. The administration of thyroid was continued under supervision.

While numerous observers have cited instances of poor ossification of the affected joint in osteochondritis, apparently no one has considered the degree of development in the other epiphyseal centers,—namely, the general developmental status. As previously stated, Hilgenreiner has described inferior epiphyseal development in the affected joint prior to the onset of osteochondritis. Engelbach and Schaefer, in reporting on endocrine dwarfism treated with an anterior lobe extract, cited the frequent occurrence of what they termed "chondroepiphysitis" in conjunction with dwarfism. Nine cases were reported out of a series of fifteen studied. From a study of the protocols, one is able to find only two of these cases reported in detail. It is significant that in both there was retardation in epiphyseal development of three and four years respectively. Shelton, Cavanaugh, and Evans did not observe any evidence of osteochondritis in a series of children suffering from hypophyseal infantilism, in every one of whom epiphyseal development was normal or only slightly retarded for the age. On the other hand, joint pains have been a rather consistent finding in a large series of children with thyroid deficiency, all of whom presented retarded bone development. The inference, therefore, is that the thyroid factor and not the pituitary factor is paramount in maintaining the normal nutritional metabolism of the osteochondral system, other things being equal.

The age period in which the disease occurs in most instances has made difficult the accurate estimation of basal metabolism. Shelton in 1931 reviewed the work of all previous authors, correlated their findings as regards normal epiphyseal ossification, and presented a chart showing the normal appearance and union of all the epiphyseal centers. He concluded that the rate of epiphyseal development was an index of metabolic speed during childhood and adolescence. Since that time, he and others (Clark and Dorff) have presented clinical material to support the value of epiphyseal studies in estimating the metabolic speed in individuals in whom accurate estimations of oxygen exchange are not possible.

The majority of authors have maintained that osteochondritis occurs in healthy, normal children in whom no conclusive evidence of metabolic deficiency is found. One author, after making such a statement, offers as the etiology an imbalance between the nutritional supply and the physiological demand in the epiphysis. The very processes of supply and demand in nutrition are intimately related to metabolism. The common practice has been to consider an individual without classical stigmata of cretinism or myxoedema as having a normal metabolic speed. The whole

question hinges on the proneness of physicians to look for a classical picture which, after all, is a terminal state of a long-standing metabolic imbalance and as slow in development as is the process of growth.

Of the five cases under discussion, enuresis was present in three,

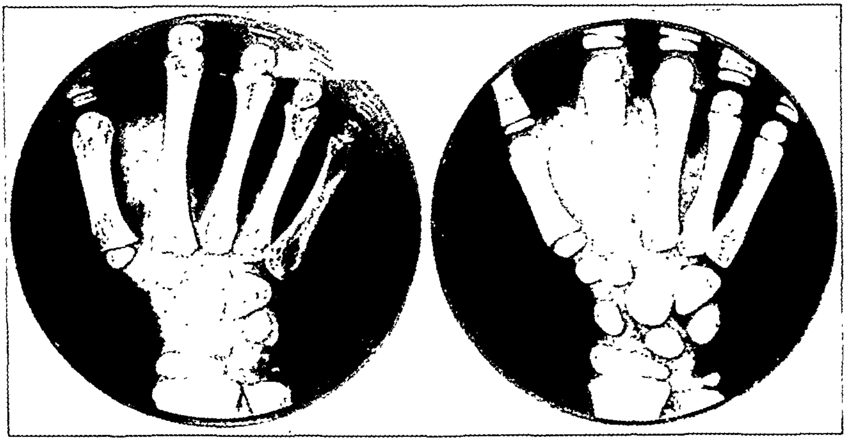


FIG. 9

Case 5. G. R. Patient's wrist (left) compared to approximate normal for age.

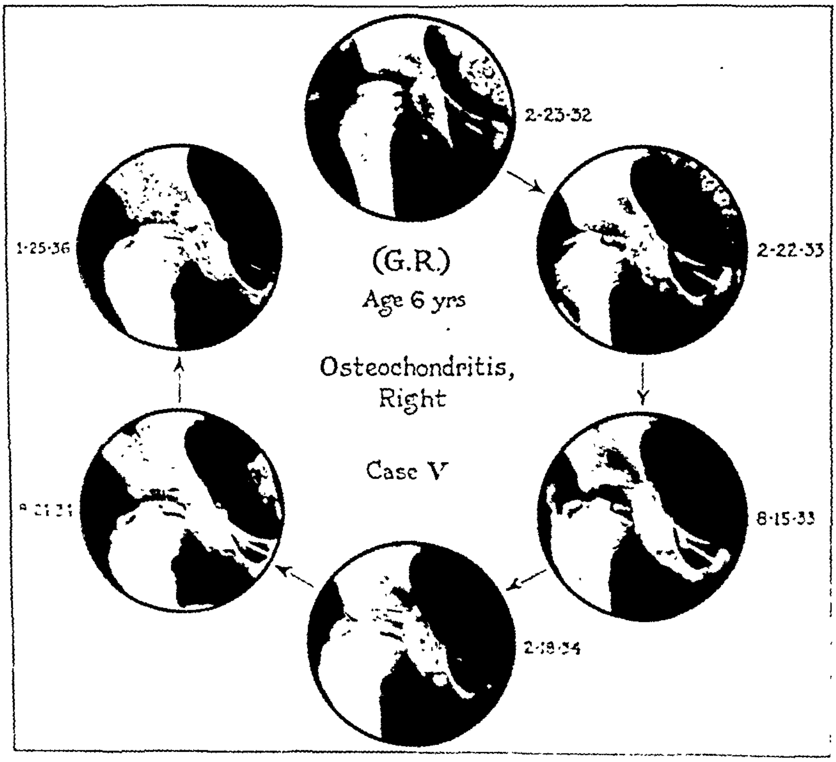


FIG. 10

retarded dentition in three, cryptorchidism in two, hypogenitalism in one, and asthma in one. None had an appearance of cretinism or of juvenile myxoedema, yet all were found to have from eighteen to thirty-six months' retardation in epiphyseal development. Frank goiter was present in three mothers and a palpable enlarged thyroid in two. A history of goiter on the maternal side was given by three patients.

In a recent survey of 560 school children between the ages of five and twelve years, Shelton reported only 12.5 per cent. as having a retardation in epiphyseal development of more than two years. Of the five cases of osteochondritis reported in this paper, 100 per cent. had such retardation. It is accepted that osteochondritis of the capital femoral epiphysis is much more common in males than in females. In this regard it is interesting that epiphyseal ossification is normally more delayed in males. Clark states that at four years females are nine months more advanced than males and at twelve years they are from one to two years more advanced. This sex difference in rate of epiphyseal ossification may partially explain the sex difference in the incidence of osteochondritis.

No attempt has been made to present a statistical study of the duration of the disease in the cases presented. It is well established that ordinarily the course extends over a period of from two to six years. The number of cases presented herewith is limited and there was so much variation in the stage of development of the disease when measures to increase metabolic speed were instituted that statistical studies would probably have been more confusing than informative. Conclusions as to the possible shortening of the morbid period from such a regimen would, therefore, be unjustified. It is interesting to note, however, the consistency with which beginning restoration of normal epiphyseal structure occurred after thyroid therapy was instituted. This is particularly evident in Cases 1 and 5.

In addition to the series reported, the authors have under observation four cases of osteochondritis of the tibial tubercle with lowered basal metabolic rates and retarded epiphyseal development in three; two cases of osteochondritis of the os calcis and one of the dorsal spine, all with lowered basal metabolic rates, retarded bone development, and other signs of hypothyroidism. These we plan to report later.

A careful analysis of the literature fails to reveal any reference to roentgenographic studies of (non-affected) epiphyseal centers in order to check the rate or the degree of development in osteochondritis. Heretofore, an individual suffering from this disturbance was commonly considered normal if otherwise free from the gross or terminal evidence of metabolic disease. The five cases presented tend to demonstrate that this conclusion is not justified until the general metabolic status is more thoroughly investigated.

Snodgrass, in 1932, reviewed the material prepared by Lippmann from one case and stated that he was greatly impressed with the similarity of the changes to those observed in normal bone repair. In a compre-

hensive review of the literature, he cites considerable evidence to support this view. If, as he suggests, osteochondritis represents changes which ensue during the stages of aseptic necrosis and normal bone repair, it is not impossible that the abnormal process is commonly the result of lowered metabolism with poor ossification in the epiphyseal centers, one or more of which fail under the stress of weight-bearing or other trauma. In this regard, it is realized that insufficient material has been studied to allow positive conclusions. The authors present the material with the hope that other investigators will study the entire osseous structure and the individual metabolic status in order to refute or to verify these findings. Eventually, sufficient material may be collected to allow a true measurement of the etiological importance of altered metabolism, particularly as regards the thyroid status, in osteochondritis.

SUMMARY

In the five unselected cases of osteochondritis of the capital femoral epiphysis presented, a high incidence of metabolic disorder—namely, colloid goiter—was discovered in the patients' families. Definite evidence of metabolic disorder, as indicated by retarded bone development and numerous other stigmata, was discovered in the patients. In three cases the disease had been present and active for from twelve to fifteen months before measures designed to raise the metabolic level were begun. The metabolic factor in the remaining two was recognized soon after the onset of symptoms. There was an early and consistent restoration of normal epiphyseal structure in all cases after thyroid therapy was instituted. The importance of more thorough investigation of the entire osseous structure, particularly as regards the rate and degree of epiphyseal ossification in osteochondritis, is emphasized.

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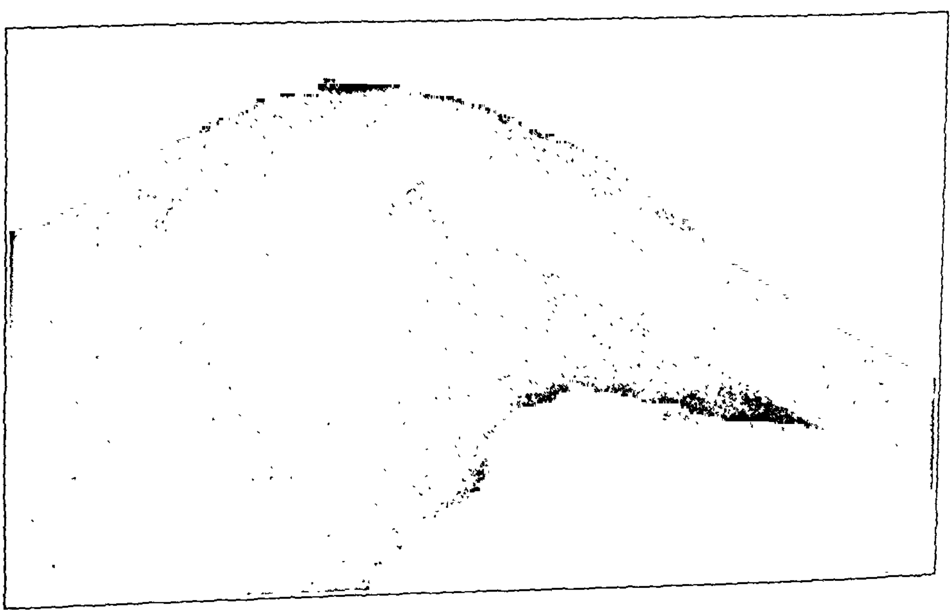

FIG. 1

Case 1. Fracture at the junction of the upper and middle thirds of the femur.

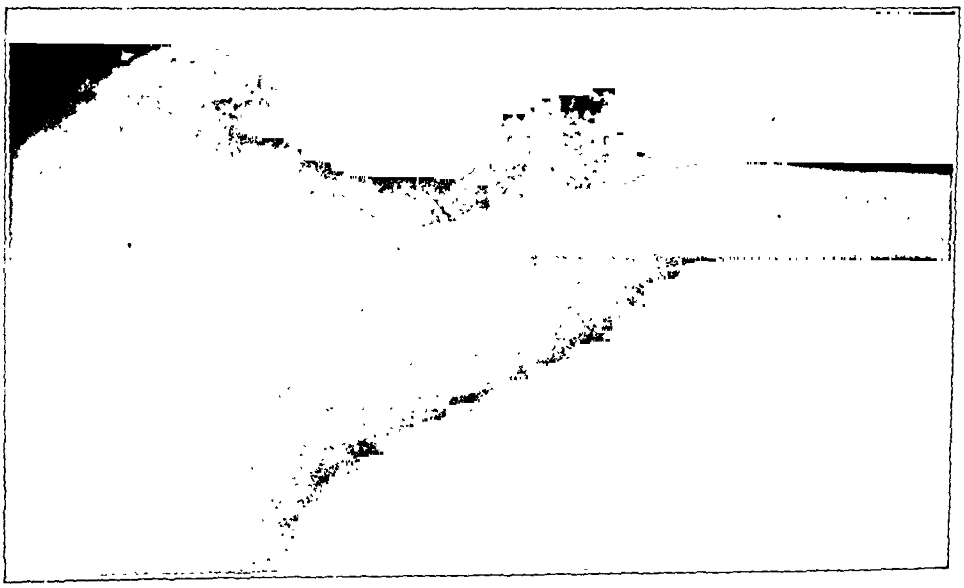

FIG. 2

Case 1. Roentgenogram, seventeen days after operation, showing a considerable amount of bony callus.

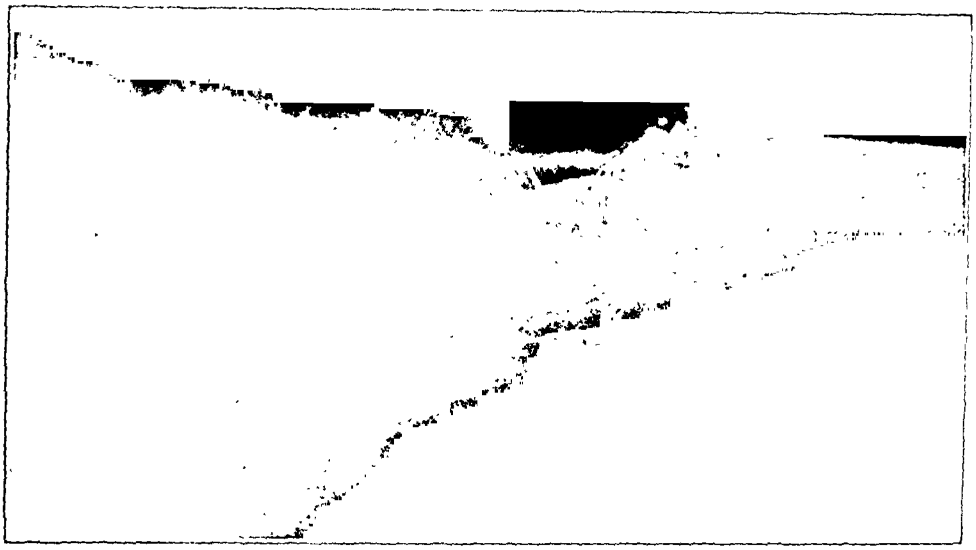

FIG. 3

Case 1. Roentgenogram taken three weeks later than Fig. 2. Note the increase in callus and the slight sequestration of the ends of the bones.

at the end of seven days. The child was allowed on crutches three weeks later, and was given a walking caliper brace on December 10, 1935 (fourteen weeks following the fracture).

CASE 2. F. V., a male, aged sixteen, of Polish extraction, was admitted to the Orthopaedic Service on August 23, 1935. He gave a history of having had pain in the right thigh coincident with generalized aching and chills six weeks previously. These complaints had become worse over a period of three weeks, at the end of which time the femur had been opened through an anterior low-thigh incision. Following surgery there had been no relief from pain and the temperature had continued.

On examination the patient was found to be pale and undernourished. The temperature was 99.5; the pulse, 120; and respirations, 25. Examination of the throat was essentially negative; the tonsils were absent. The heart and lungs were normal except for a tachycardia. Examination of the abdomen was negative. The reflexes were not unusual. There was a ten-centimeter wound on the anterior aspect of the lower third of the right thigh. A gauze pack was present. The entire thigh was hot. There was no limitation in hip motion.

The laboratory findings were as follows:

Red blood cells—3,810,000
Hemoglobin—70 per cent.
White blood cells—10,300

FIG. 4-A

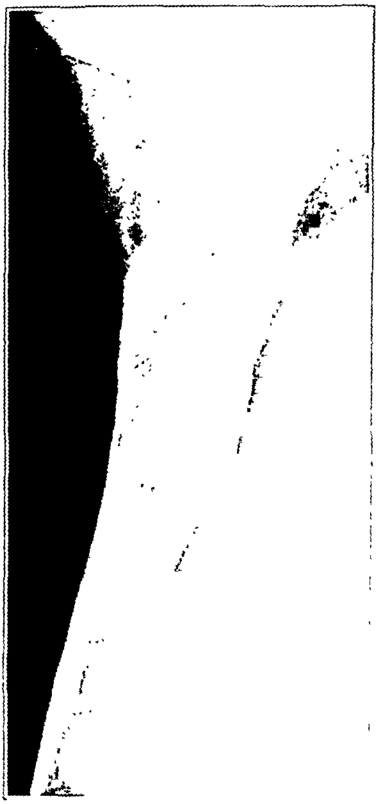

FIG. 4-B

Case 1. Roentgenograms taken forty-four days after operation. Firm bony union has occurred and there is one inch of shortening.

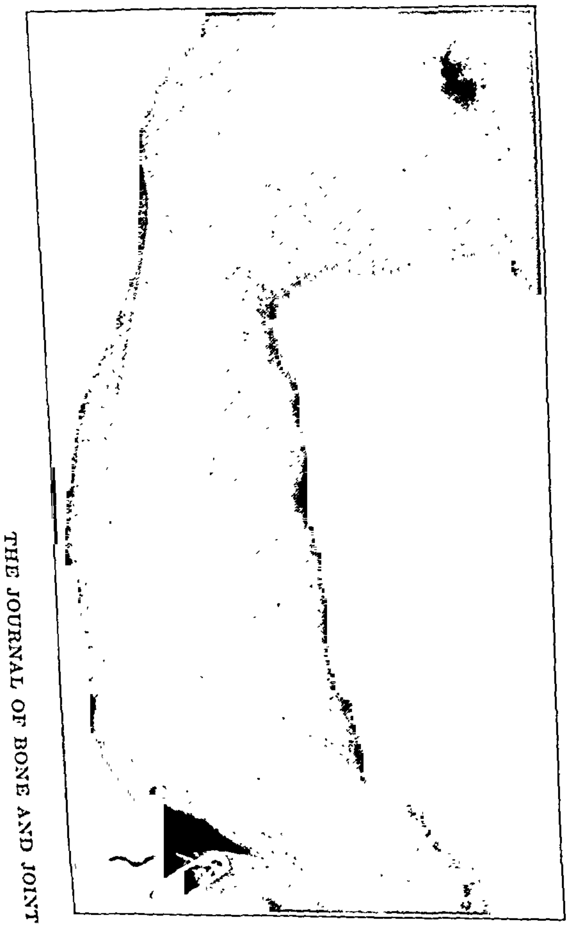

Fig. 5

Case 2. Fracture of the lower end of the femur. The lower fragment is markedly angulated, rotated, and overriding.

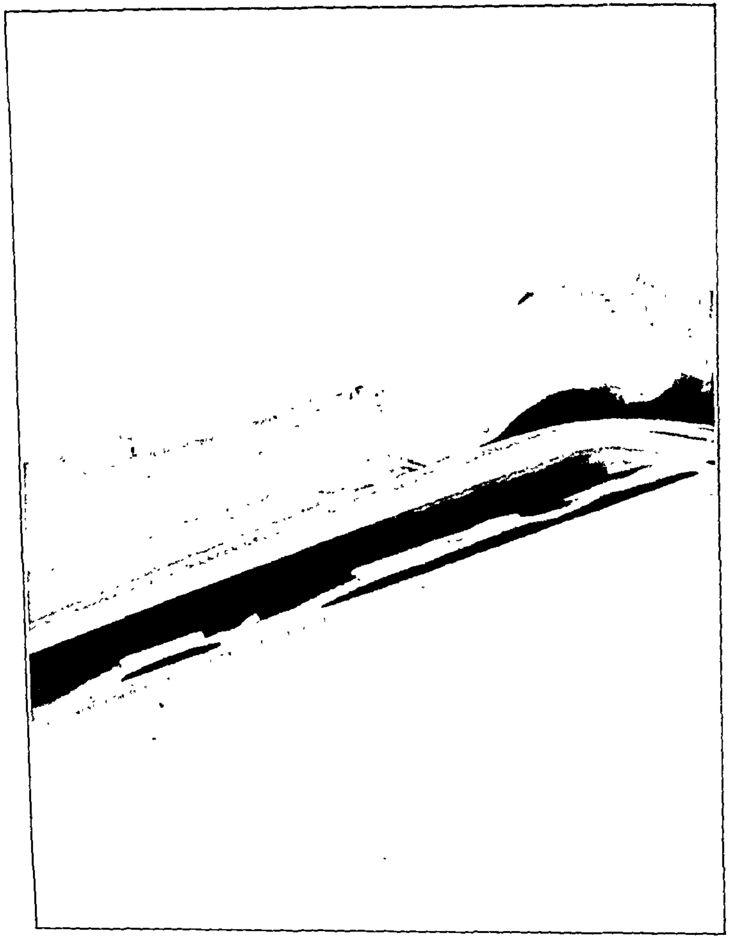

Fig. 6

Case 2. Roentgenogram, taken eighteen days after operation, showing a considerable amount of bony callus and the fragments in good position.

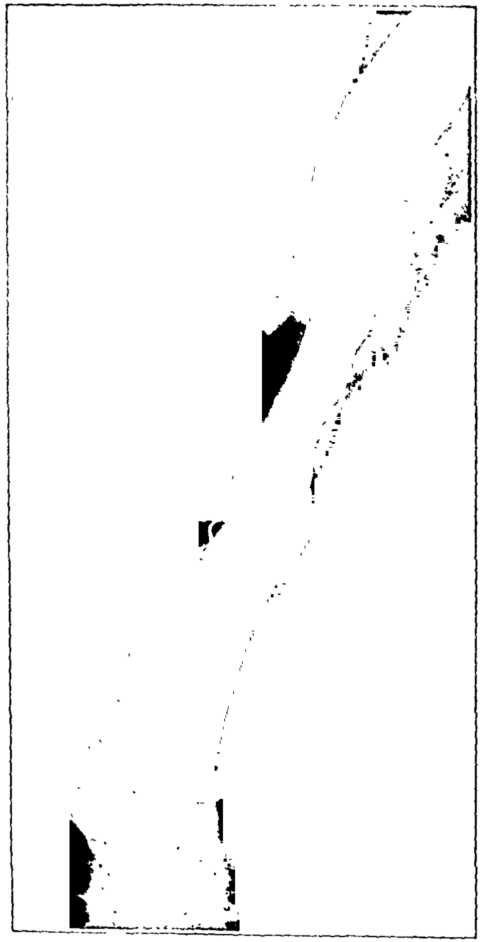

Fig. 7

Case 2. Roentgenogram taken five weeks after Fig. 6. Note the abundant callus.

Polymorphonuclear neutrophiles—73 per cent.
Small lymphocytes—12 per cent.
Large lymphocytes—7 per cent.
Transitional cells—5 per cent.
Eosinophiles—2 per cent.
Basophiles—1 per cent.

Kahn test, negative; urine, negative except for a trace of albumin.

The diagnosis was evident, and the boy was operated upon on the fourth day. The usual gutter was made and packed wide open. A culture of the material obtained was reported as pure staphylococcus aureus.

The postoperative recovery was good and on the twelfth day the patient was transferred to the Convalescent Home. The wound healed well and the general condition improved over a period of three months. At this time the boy complained of pain in the leg and showed a moderate elevation of temperature. The pulse rose to 130. The patient was transferred to the hospital and the femur was again exposed. A sinus was found which led through the entire cortex to the medial side of the shaft and which contained a few small sequestra. This was curetted and packed.

On the tenth postoperative day an abnormal contour of the thigh was noted. There was an obvious bowing of the leg laterally. Roentgenograms revealed a fracture of the lower end of the femur; the lower fragment was markedly angulated, rotated, and overriding (Fig. 5). At no time had the patient complained of any unusual pain aside from that which was expected from the surgery.

The boy was returned to the hospital for operation. The bone ends were exposed and the fragments were curetted until bleeding was obtained. Grossly there appeared to be no periosteum about the fracture site. One piece of rustless steel wire was used to hold the fragments in firm apposition. The soft parts were allowed to fall back into place. The leg was placed on a modified Böhler frame. A Kirschner wire was put through the tibial crest and ten pounds of traction was applied.

Eighteen days later roentgenograms demonstrated a considerable amount of bony callus with the fragments in good position. (See Figure 6.) The wound drained freely. The temperature peaks reached 102. Five weeks later clinical examination gave the impression of union. Roentgenograms at this time revealed abundant callus. (See Figure 7.) The frame and traction were removed, and on March 23, 1936 (thirteen weeks following the fracture) the patient was given a walking caliper brace.

COMMENT

It is to be noted that Case 1 was purely traumatic and that Case 2 was pathological in character. In the latter case the bone appeared unhealthy and at the time of wiring little hope was held for solid union.

Close examination of the roentgenograms demonstrates very little, if any, bone production along the lateral aspect of the shaft in the guttered area. On the contrary, callus is clearly seen appearing on the medial and posterior aspects of the femora. * These areas were not disturbed surgically except for drilling. These observations would indicate that for the most part the repair comes from the periosteum and not from the cortical bone.

* Since the inception of this paper a third case has come under our observation which shows the appearance of callus as described above,—abundant production medially and posteriorly on the shaft of the femur.

THE OCCURRENCE OF ABSCESSES FROM TUBERCULOUS HIPS THAT ARE FIRMLY ANKYLOSED *

BY Z. B. ADAMS, M.D., BOSTON, MASSACHUSETTS

Many methods have been developed and described as the proper and best way to produce ankylosis in tuberculous hip disease. However, in the author's opinion there is no one method which is applicable in every case. The operation must be varied according to the conditions found when the hip joint and surrounding structures have been exposed at the time of operation. This is especially true when a previous operative fusion has failed.

The pedunculated graft, including the outer cortex of the ilium and hinged at the capsule if possible, is a good method, but in children under ten years of age the graft becomes cartilaginous where it is surrounded by the cartilage of the trochanteric epiphysis, and it is two or three years before this attachment becomes bony and is solid. (See Figures 1-A and 1-B.)

Moreover, it is the writer's belief that a graft extending from the ilium to the trochanter, as produced by this method, or by the methods of Hibbs, Albee, or Bristow, is not enough. The head still moves in the socket even when the graft has attached itself to the ilium and to the trochanter, and these grafts not infrequently break. (See Figure 2.)

From his experience at the Lakeville State Sanatorium the author has been led to believe that the Hibbs, Wilson, Bristow, or Albee operations alone are not enough to lock the hip, and that it is advisable if possible to do at the same time Ghormley's operation (as in Case 7850) or a similar procedure to steady the head in the socket.

In general the writer considers that operations which require disarticulation of the head are not good. If the head and socket are stripped of cartilage, the head is loosened in the socket and is less likely to become attached.

Table I lists forty-eight cases of tuberculous hips treated at the Lakeville State Sanatorium. In all of these cases the hips became firmly ankylosed. In eighteen cases the ankylosis was spontaneous. In nine, or 50 per cent., of these eighteen cases sinuses persisted after bony ankylosis had taken place, and in one case (8049) an abscess developed fifteen years after bony ankylosis was complete.

In thirty of the forty-eight cases operation for ankylosis was performed, but not all of these operations were done at the Lakeville State Sanatorium, for some of these patients were sent to the Sanatorium for convalescence after the operation. In six of these thirty cases (20 per cent.) abscesses developed after ankylosis was clinically firm.

In three of these cases (6672, 7145, and 7279) the bone-flap operation

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 20, 1936.

TABLE I

RÉSUMÉ OF FORTY-EIGHT CASES OF ANKYLOSIS OF TUBERCULOUS HIPS SEEN AT LAKEVILLE STATE SANATORIUM DURING THE THREE-YEAR PERIOD TO MARCH 13, 1936

Case No.	Initials	Operation for Ankylosis	Sinuses	Final Result
7117	J.F.	No	Multiple	Sinuses continued.
7250	S.M.	No (Osteotomy to correct position)	Yes	Sinuses closed. Good result.
7323	C.T.	No	No	Firm ankylosis.
7430	P.G.	Yes	Yes	Sinuses closed.
7453	D.Z.	No	Multiple	Sinuses continued.
7470	H.B.	Yes	No	Firm ankylosis.
7460	M.S.	No	Yes	Sinuses closed.
6561	J.Y.	No	Yes	Sinuses closed.
7602	A.K.	No	Yes	Firm ankylosis. Sinuses open. Died.
7628	L.G.	No	No	Firm ankylosis.
7664	P.G.	No	No	Firm ankylosis.
7619	A.H.	Yes	Yes	Firm ankylosis. Profuse discharge. Died.
7895	A.C.	No	Yes	Firm ankylosis. Sinuses continued.
7042	C.S.	Yes	No	Firm ankylosis.
7430	P.G.	Yes	Yes	Firm ankylosis. Sinuses closed.
6544	A.G.	Yes	No	Firm ankylosis.
7059	A.B.	Yes	No	Firm ankylosis.
7071	A.B.	Yes	No	Firm ankylosis.
7074	T.K.	Yes	Yes	Firm ankylosis. Slight drainage.
7114	E.O.	Yes	No	Firm ankylosis.
7119	F.M.	Yes	No	Firm ankylosis.
7444	J.D.	No	Yes	Firm ankylosis. Sinuses continued.
7558	A.L.	Yes	Yes	Firm ankylosis. Sinuses closed.
7251	N.J.	No (Osteotomy)	No	Firm ankylosis.
7247	N.J.	Yes	No	Firm ankylosis.
7406	I.S.	No	No	Firm ankylosis.
7153	O.	No	No	Ankylosed in good position.
6997	T.D.	Yes	Yes	Firm ankylosis. Sinuses closed.
7174	J.W.	Yes	No	Firm ankylosis.
7279	V.R.	Yes	Yes	Firm ankylosis. Sinuses continued.
7122	W.R.	Yes	Yes	Firm ankylosis. Sinuses healed.
7694	S.K.	Yes	Yes	Firm ankylosis. Sinuses continued.
7555	E.P.	Yes	No	Firm ankylosis.
7360	A.B.	Yes	No	Firm ankylosis.
7218	M.O.	Yes	No	Firm ankylosis.
7835	L.G.	Yes	No	Firm ankylosis.
7707	A.F.	No	Yes	Firm ankylosis. Sinuses continued.
7488	W.C.	No	Yes	Firm ankylosis. Sinuses continued.
7177	W.W.	Yes (Graft not holding)	No	Firm ankylosis.
7850	L.G.	Yes (Double operation)	No	Firm ankylosis.
8049	A.A.	No	Yes	Firm ankylosis. Sinuses continued.
6651	J.W.	Yes	No	Firm ankylosis.
4635	W.D.	No	Yes	Firm ankylosis. Sinuses continued.
7238	E.H.	Yes	No	Firm ankylosis.
6672	H.C.	Yes	Yes	Firm ankylosis. Sinuses continued.
6831	A.S.	Yes	No	Firm ankylosis.
7145	B.S.	Yes	Yes	Firm ankylosis. Sinuses continued.
6940	F.M.	Yes	Yes	Firm ankylosis. Sinuses closed.

described by Wilson was the only procedure used. In one case, although the hip clinically appeared locked, the fact that the sinuses led to the deep socket inside the pelvis (Fig. 3) seemed to indicate that the head must have moved slightly in the socket.

CONCLUSIONS

In the treatment of tuberculous hips the following points should be emphasized:

1. The operation to lock the hip should fix the head as well as the trochanter in order to prevent development of abscesses.
2. Abscesses may develop and sinuses may continue to drain when there is clinically solid bony ankylosis.
3. A solid bony ankylosis is, nevertheless, the best result that can be obtained and is the least likely to cause subsequent abscess formation.

A NEW USE FOR THE KNICKERBOCKER TONGS

Correction of Diastasis after Reduction of Rare Ankle Fracture (Maisonneuve-Cotton Type)

BY EDWARD RAYMOND EASTON, M.D., F.A.C.S., NEW YORK, N. Y.

Ashhurst, whose monumental work on the classification of ankle fractures will probably stand the test of time, divided them according to mechanism into five groups, with subclassifications: (1) fractures by external rotation; (2) fractures by abduction (fibular flexion); (3) fractures by adduction (tibial flexion); (4) fractures by compression in the long axis; and (5) fractures by external violence (supramalleolar type).

The fracture of the posterior lip of the tibia, resulting in backward displacement of the foot, was practically always, in Ashhurst's opinion, a complication of the first type (external rotation). It was first described by Cooper in 1822, but in 1915 Cotton mentioned it as a new type of fracture. Cotton believes that all major fractures about the ankle present some features of a dislocation as well, in that there is at times a considerable displacement of the foot. He divides them into four different types from the standpoint of treatment: the Pott's fracture, the reversed Pott's fracture, the so called "Cotton's fracture", and the compression fracture.

The writer believes that all four types of fracture can occur without much widening of the mortise and without marked laceration of the inferior tibiofibular ligaments. While in some cases the ankle mortise is satisfactorily restored, in others diastasis persists after the fracture has been successfully reduced. This condition is readily recognized by measurement with carpenter's calipers of the distance between the tips of the two malleoli.

The widening of the mortise has been corrected by means of screws, bolts, and other mechanical devices which will approximate the tibial and fibular fragments. This, however, necessitates an open operation and exposes the patient to the danger of infection. Cotton mentions the use of tongs in compression fractures, but, so far as the writer can discover, this method has not been employed before for closing the ankle mortise *per se*.

The first case herewith reported is an unusual type of fracture of the upper third of the fibula. It was described in 1840 by Maisonneuve, who had never seen the condition clinically but who was able to produce it experimentally on cadavera. It is a

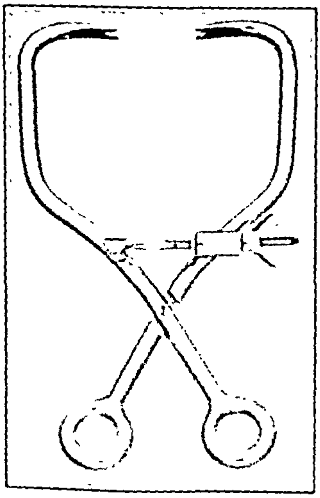

Fig. 1
The Knickerbocker tongs.

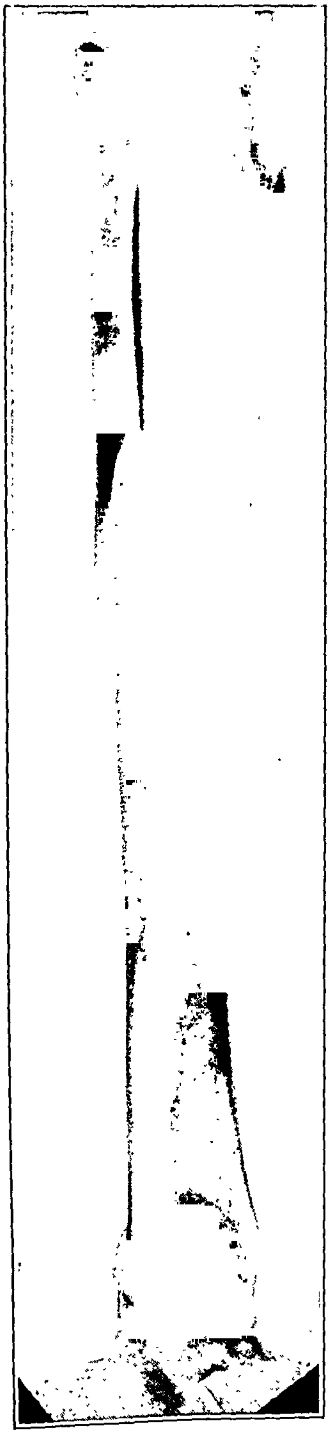

FIG. 2

Lateral view, showing torsion fracture of the upper third of the fibula and fracture of the posterior lip of the tibia, after reduction of posterior displacement.

torsion fracture, such as is always associated with rupture of the internal lateral and inferior tibiofibular ligaments. As in the present case, it is usually complicated by a fracture of the posterior margin of the tibia and by a posterior displacement of the foot as in Cotton's fracture. Since it was described by Maisonneuve, the torsion fracture of the fibula has been recognized clinically on account of its unusual features. Ashhurst, who had a case of this type in his collection of 300 ankle fractures, quotes Destot as having treated four Maisonneuve fractures with an associated fracture of the posterior lip in a group of 1,700 cases.

The mechanism is, without doubt, that of external rotation, which results in the sudden giving way of the internal lateral and inferior tibiofibular ligaments, allowing a widening of the ankle mortise. This is accompanied immediately by a compression fracture of the posterior lip of the tibia, caused by an upward and backward thrust of the astragalus and a backward dislocation of the foot. This is followed by a torsion fracture of the upper third of the fibula.

In the following case this mechanism was undoubtedly the cause of the fracture.

T. Q., aged thirty-two, a white male, weighing 200 pounds, with no occupation, fell on an icy sidewalk and was admitted to the Knickerbocker Hospital January 21, 1936. Although the patient was inebriated at the time and could not state clearly how the accident had happened, it was apparent that the weight of his body had produced the series of lesions.

Physical examination elicited clicking on movement from side to side of the right foot and ankle. Prominence of the tibia anteriorly at the ankle and dislocation backward on the astragalus were noted. Intermalleolar measurement showed widening of two centimeters of the mortise of the right ankle as compared with that of the left ankle. Shortening of the leg, amounting to one centimeter, was present.

Roentgenographic examination disclosed a spiral fracture of the middle third of the shaft of the fibula, with the fragments in fairly good position. There was also a fracture through the distal end of the right tibia near its posterior aspect with spreading of the ankle mortise.

The luxation of the foot and the fracture of the posterior margin of the tibia were easily reduced, but the diastasis of two centimeters between the malleoli and the shortening of the leg by one centimeter still remained. Posterior molded and hairpin

plaster-of-Paris splints were applied, with the foot in dorsiflexion and inversion in midposition.

On January 22, the hairpin splint was removed and the malleoli were exposed, the posterior molded splint being left in place. Under ether anaesthesia, the Knickerbocker tongs were applied as follows: Half-inch incisions were made down to the bone at points one-half an inch above the internal malleolus and one inch above the external malleolus. The prongs of the tongs were adjusted to the ridges of both bones through the small wounds and approximated by a thumb-screw. Dry sterile dressing was then applied. The posterior molded splint was so placed that the tongs encompassed it at the sole of the foot. Lateral plaster splints extended down to one inch above the malleoli and were bandaged in place. Two plaster bandages incorporated the tongs, splint, and foot in dorsiflexion and prevented joggling. Three pounds of traction was applied.

On the same day, roentgenographic examination showed reduction of the diastasis.

On February 20 the tongs were removed, and there was no evidence of infection in the wounds. Sterile vaselin gauze was applied, and two plaster bandages were placed circularly around the foot and the ankle. On March 7 the plaster splints were cut off just below the knee to allow flexion.

The entire cast was removed on March 17, and the wounds caused by the tongs were found to be completely healed. There was only moderate swelling around the ankle. Roentgenographic examination showed the bones approximated, exactly as they were on January 22 after application of the tongs. Outside measurements of both ankles were the same. There was no shortening of the leg. Movements of the right ankle and the subastragalar joints were comparatively free considering the eight weeks' confinement in splints. The foot showed no backward displacement relative to the articular surface of the tibia; the fracture was healed with moderate callus; and the weight-bearing line appeared to be normal. The leg was firmly strapped with an adhesive stirrup, and the patient was instructed not to bear weight for at least two more weeks.

On March 30, 1936, the patient walked without a limp. The integrity of the inferior tibiofibular joint was restored. Movements of the ankle and the foot were functionally perfect.

The traction tongs used in this case were evolved by the writer early in 1934, and have since been giving excellent results in skeletal traction. It was at the suggestion of Dr. Ellsworth Eliot, Jr., Director of Surgery at the Knickerbocker Hospital, that they were tried in this case for the first time to correct a diastasis of the malleoli in a fracture of the ankle. Due to the corrugation of the inner surface of the prongs and their termination in two points instead of one, a large gripping surface is afforded which holds firmly without puncture of the bone cortex. A lock screw prevents slipping, and there is no danger of piercing the bone by added traction. (See Figure 1.)

A second case was treated at Knickerbocker Hospital by an associate, Dr. William A. Fraser.

J. M., aged forty-five, a carpenter, was admitted on July 28, 1936, with a severe compound fracture and dislocation of the right ankle of the supramalleolar type, with marked diastasis; also multiple fractures of the pelvis and dislocation of the right shoulder. The patient was in shock. Dr. Fraser first inserted a Steinmann pin through the os calcis, but the dislocation recurred. At Dr. Eliot's suggestion he applied the Knickerbocker tongs. Immediate restoration of the fragments to their proper relation, with normal contour of the ankle joint, was visible. Despite violent delirium from pneumonia and alcoholism, this position was maintained until the patient's death thirty-six hours later.

There appears to be very little mention in the literature of repair of

FIG. 4

Anteroposterior view, showing closure of the ankle mortise after application of the Knickerbocker tongs.

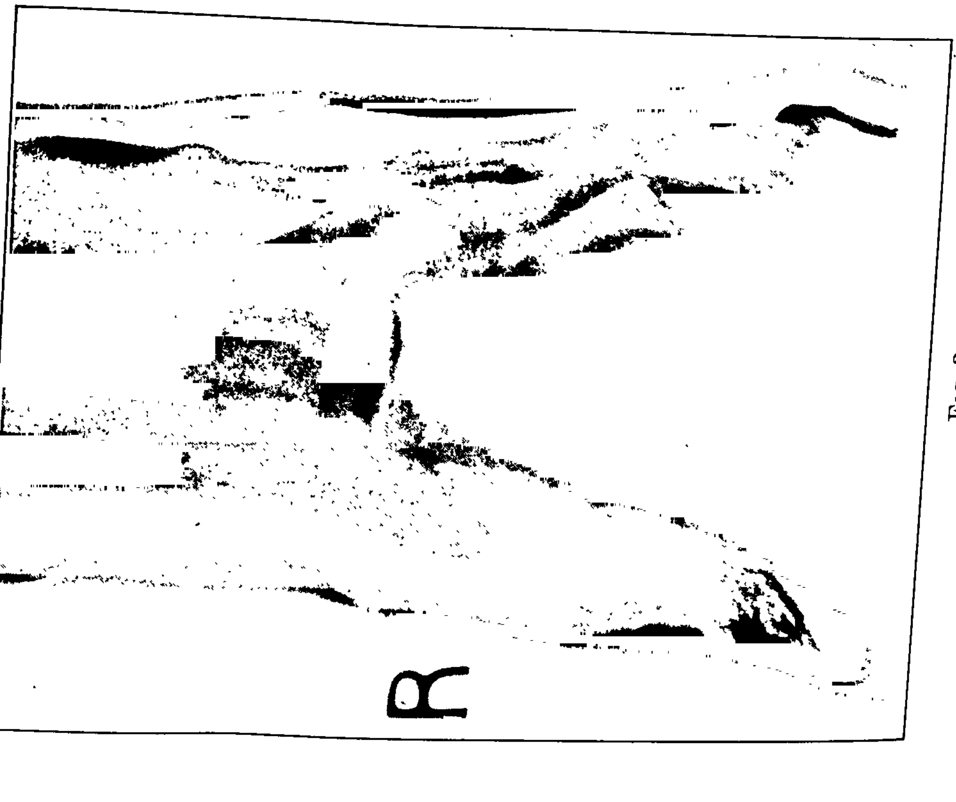

FIG. 3

Anteroposterior view, showing diastasis of the tibiofibular articulation after application of plaster splints.

the ankle mortise and end results in diastases of this kind. Cotton suggests that the separation between the malleoli is easily overlooked, due to the overlapping of bones in the anteroposterior roentgenogram. Diastasis may, therefore, be present when there is no open gap apparent between the tibia and the fibula. To quote from Cotton:

"Operations most ingenious have been devised to remedy this condition. In fresh cases, however, the deformity can be reduced by downward traction on the foot combined with compression about the malleoli; the foot should be held in varus posture. The unreduced lesion is disabling. This condition must always be considered in diagnosis and treatment of ankle fractures."

The statement that the deformity (widening of the mortise) can be reduced by downward traction of the foot suggests another form of treatment,—namely, the Steinmann nail through the os calcis, with the traction or the distraction method of Bosworth.

The treatment by the tongs as advocated here is indicated only in those cases in which widening of the mortise persists after reduction has been accomplished. In posterior marginal fracture with involvement of the internal malleolus, the application of tongs may be difficult, though possible. In no case should tongs be used unless they can be so placed as not to exert pressure on the line of fracture with consequent separation of the fragments. It must be emphasized that the object of this method in the treatment of ankle fractures is only to correct the diastasis of the inferior tibiofibular joint, and not to reduce the fracture.

In general, it is the writer's opinion that the method of treatment adopted in this case will give results as good as, or more satisfactory than, other methods suggested. It is recommended that its actual value should be determined by its use in a considerable number of cases. At least it may be said that the possibility of infection is much less than when the diastasis is corrected by the use of screws, bolts, nails, or other mechanical appliances.

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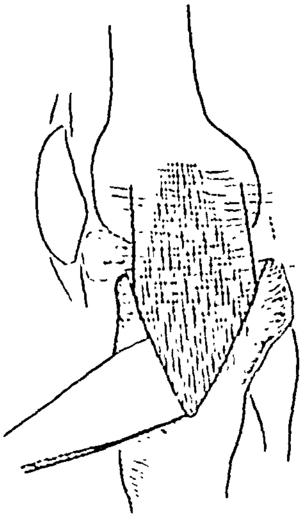

FIG. 2

Removal of the bone flap from the inner head of the tibia. Incisions extend upward through the capsule.

is removed and reflected upward. This section of bone is from one and one-half to two inches in length and about half an inch thick at the articular surface, and is triangular in shape (Fig. 2). At the joint surface the capsule is split upward for about an inch at both the anterior and posterior margins of the bone flap. As the flap of the capsule with the bone attached is reflected (if it has not been removed), the internal semilunar cartilage will be seen to be attached to the flap but still bound to the head of the tibia at its anterior and posterior ends (Fig. 3). After full reflection the cartilage is removed with scissors from its attachment to the inner aspect of the flap. When the flap is fully turned up, the whole inner aspect of the joint is exposed and, by flexion and abduction of the leg on the thigh, the fat pads, the crucial ligaments, and the interior of the joint in both the anterior and posterior aspects can be examined (Fig. 4).

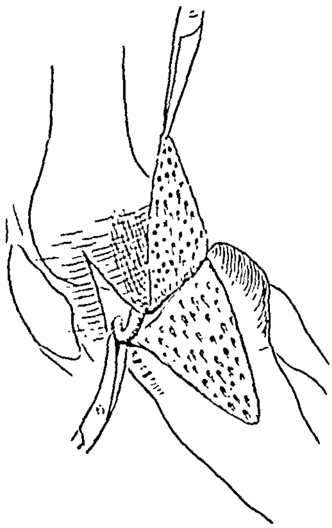

FIG. 3

Removal of the attached internal semilunar cartilage as the flap is reflected upward.

To shorten the ligament, the ligament and bone flap are drawn strongly downward and the point to which the articular surface of the bone flap can be brought is marked by a chisel cut. This distance has averaged three-quarters of an inch in the writer's cases with a maximum of one and one-quarter inches. One-quarter of an inch below this point, a notch is chiseled in the side of the tibia according to the depth and width of the bone flap. Additional bone is then removed from below to accommodate the flap. At the lower end a small shelf of overhanging bone is left under which the lower end of the transplanted bone flap can be slipped and locked. The upper margin of the area of the tibial end is beveled upward and inward, and the upper articular surface of the bone flap is denuded of the cartilage by beveling downward and out-

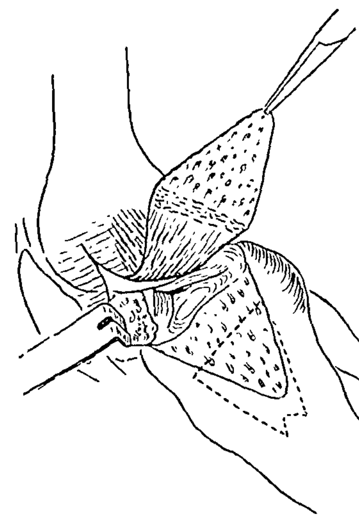

FIG. 4

Exposure of the interior of the joint, obtained by abducting the tibia on the femur. Note the outline of the new bed for the transplanted bone flap.

ward (Fig. 5). The bone flap is then mortised into the new bed and locked by slipping the lower end of the flap, which has been slightly shortened, under the overhanging shelf of bone (Fig. 6). It should be noted that the part of the ligament formed by scar tissue is brought against the denuded bone of the tibial head above the new bed. The inner surface of this part of the capsule should be scarified, so that in healing it will be firmly adherent to the bone and entirely eliminated from the shortened ligament.

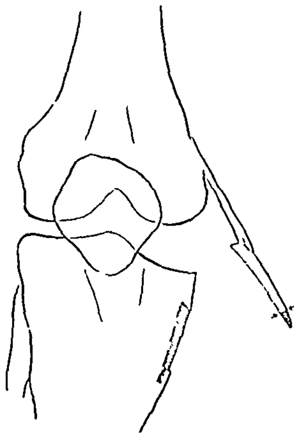

FIG. 5

Showing the beveled upper surface and the overhanging shelf of the new bed to allow mortising of the transplanted flap.

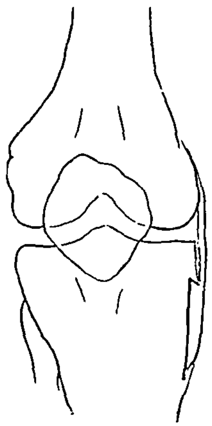

FIG. 6

Transplanted flap in position, showing the locking of the flap and the denuded portion of the capsule approximated to the raw bone above the flap.

The whole bone flap can be implanted forward on the new bed if one wishes to increase the obliquity of the anterior fibers of the ligament which might act as an additional check on any forward movement of the tibial head on the femur. This has not been necessary in any of the writer's cases.

The anterior and posterior incisions of the capsule are closed with catgut (Fig. 7). Plication of the capsule by overlapping of the edges of these incisions with mattress sutures would strengthen the inner side of the capsule if this was thought necessary. The skin is closed in the usual manner. A hinged cast is applied. The knee is kept quiet for the first two weeks and the patient is then allowed to be up with use of the leg and graduated exercises for the development of the quadriceps. Use of the hinged cast is advocated for six weeks.

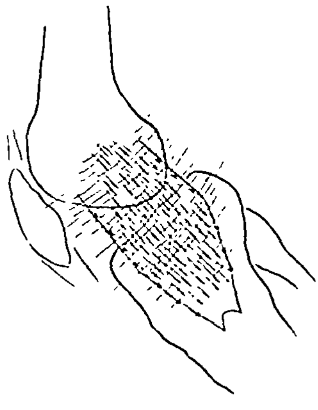

FIG. 7

Suture of the capsule and fibrous covering of the flap.

The author has operated on five cases with excellent results.

CASE REPORTS

CASE 1. W. H. H., male, forty-nine years old, an iron worker, was seen on May 7, 1931, with a history of having severely injured the right knee in a fall from a scaffold eleven months previously. The patient had been treated by a cast and a knee cage for six weeks. Two months later, the cartilage had been removed, with no improvement. Physiotherapy and a brace had then been employed for four months, followed by the use

of an elastic knee support. The patient had been unable to return to work because of weakness and pain in the knee.

Examination of the right knee showed scar over the inner side of the joint and tenderness over the head of the tibia. The right thigh was one and one-half inches smaller than the left. There was motion in abduction with the knee extended to 25 degrees (estimated). The rocker test was negative. Roentgenographic examination was negative for bone injury.

At operation the internal lateral ligament was shortened by transplantation of the tibial attachment.

A cast was worn for eight weeks, followed by physiotherapy. The patient returned to work in four months.

Examination two years later showed a perfectly stable knee and full motions. The right thigh was half an inch smaller than the left.

CASE 2. M. C., a colored female, aged twenty-seven years, was first seen on October 5, 1931. The patient complained of a weak and painful right knee. She stated that three years previously she had fallen on the ice and had dislocated her knee. She had been treated by the family physician, who had applied a splint for two weeks, and who had also used local applications. No other treatment had been given. The knee had remained weak and had frequently given way. The patient had gradually become worse and had used crutches for the past fourteen months. At the time when she was seen by the author she was unable to bear weight on the leg.

Examination of the right knee disclosed marked atrophy of the thigh and calf. There was no real swelling of the joint and no tenderness. The knee could be fully flexed and extended actively. There was motion in abduction with the knee extended to 35 degrees. The inner surface of the tibia could be separated by two fingerbreadths. Definite anteroposterior movement of the tibia on the femur was present. There was contracture of the tendo achillis, so that the foot could not be flexed quite to a right angle. Roentgenographic examination was negative for bone injury.

A diagnosis of torn internal and crucial ligaments was made. On October 6, 1931, under gas anaesthesia, the contracted tendo achillis was stretched; the foot was brought up to just beyond a right angle; and a cast was applied. This cast was worn for ten days and then a hinged cast was applied. The patient was given exercises and encouraged to use the leg.

At the end of six weeks the patient was again seen, at which time she walked very well in the cast. The cast was removed and definite improvement in the musculature of the thigh and the leg was noted. There was still considerable lateral and anteroposterior play. The patient was advised to continue the use of the knee and exercises, and the inner side of the heel was elevated a quarter of an inch. The patient returned in two weeks and stated that the knee had given way several times and was painful. Examination at this time showed increase in fluid with some swelling of the joint.

On December 11, 1931, the cartilage was removed, and examination of the inner side of the joint showed that both crucial ligaments had been torn and had almost entirely disappeared. The internal lateral ligament was thinned in its lower part. The ligament was shortened by transplantation of the tibial attachment and by plication of the capsule along the anterior incision with mattress sutures.

A straight cast was worn for four weeks, after which a hinged cast was applied. Use of the knee was encouraged and exercises were employed for eight weeks. Seven months after operation examination showed the right thigh to be the same size as the left; there was still moderate anterior motion of the tibia on the femur when the knee was flexed.

In a communication eighteen months after operation the patient stated that she was working regularly as a cook and that the knee gave her no trouble.

CASE 3. R. G., male, a filling-station employee, was seen in June 1932, with a history of having injured the left knee four months previously when a truck had backed into him. The knee was badly bruised and swollen and had been bandaged by a local doctor for four weeks. During this time the patient had been on crutches. Roent-

genographic examination had disclosed no fracture. The knee had remained swollen and "wobbly", and the patient had used a cane ever since he had discarded the crutches.

Examination of the left knee revealed considerable swelling over the inner side of the joint and tenderness over the head of the tibia and the anterior end of the internal cartilage. There was abduction of 20 degrees of the tibia on the extended femur. There was limited extension of the knee to 10 degrees and motion in flexion to 110 degrees. The rocker test was negative. The left thigh was three-quarters of an inch smaller than the right. Roentgenograms showed definite spur formation at the inner margin of the head of the tibia.

At operation the internal lateral ligament was shortened. The internal semilunar cartilage showed a longitudinal tear (bucket-handle type). This cartilage was completely removed.

A hinged cast was applied and use of the knee and exercises were allowed after two weeks. The cast was removed after six weeks.

Examination fourteen months later showed a perfectly stable knee. The patient stated that he was playing semi-professional baseball.

Case 4. P. L., male negro, thirty-two years of age, a stevedore, was first seen in October 1932 because of a "weak knee". He stated that nine months previously while at work his right leg had been caught in a "hoist" rope and he had been thrown into the hold of a ship. He thought that his knee had been pulled out of joint. He had been treated at the Marine Hospital and had worn a cast for four weeks. Three weeks later, the cartilage had been removed. He had been unable to work as the knee gave way and became painful.

Examination showed some swelling of the right knee with excess fluid in the joint and tenderness over the head of the tibia. There was abduction of 20 degrees of the tibia on the femur. Definite forward motion of the tibia on the femur was present. Roentgenographic examination revealed an increase of the joint space and irregularity of the tibial spine. No fracture was present.

The usual operative procedure was employed. On examination, the crucial ligaments were found to be intact but relaxed.

A hinged cast was applied and exercises were given for eight weeks.

Examination, six months later, showed a stable knee. The rocker test was negative. There was some soreness on prolonged use, but the patient was able to drive a delivery truck.

Case 5. M. D., a white school boy, seventeen years of age, was first seen in June 1935. He had injured his left knee a number of times playing football, and the knee locked and swelled three or four times a month.

Examination showed a powerfully built young man; he weighed 230 pounds and his height was six feet, three inches. The left knee revealed some swelling, tenderness over the head of the tibia and the cartilage, some atrophy of the thigh, and slight lateral and anteroposterior play. The roentgenograms were negative for bone injury.

At operation through the Jones incision, the torn cartilage (bucket-handle type) was removed and after three weeks the patient was given exercises and was permitted to use the knee. Following operation, the knee remained weak and slipped back and forth in spite of exercises. Six months later, the knee continued to slip and to give way. Examination showed the quadriceps to be well developed; the left thigh was half an inch smaller than the right. There was motion in abduction with the knee extended to 15 degrees. The rocker test was positive.

In January 1936, the usual operation was performed. There was some drainage from the wound after one week. The knee was kept in a cast for nine weeks; hinges were not used. After removal of the cast the patient was permitted to use the knee and was given exercises.

Four months after the operation, examination revealed the thigh muscles to be still

somewhat atrophied, but the patient walked well. There was no lateral motion with the knee straight and no anteroposterior play.

This paper is offered to describe an operative procedure to remedy the instability of the knee due to injuries of the internal, lateral, and crucial ligaments. To the author it seems theoretically sound; mechanically it has proved simple but accurate, and in the few cases in which it has been used it has given satisfactory results.

MELORHEOSTOSIS LÉRI

A Case Report

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In 1922 Léri and Joanny reported a type of bone pathology previously undescribed, to which they applied the descriptive name of "melorheostosis" or "flowing hyperostosis of a limb". The characteristic lesion is revealed by roentgenograms which show a dense, eburnated, linear streaking of the bones of an extremity, often beginning in the scapula or pelvis and extending along one side of the long bones into some of the carpal or tarsal bones, causing Léri to liken the appearance to a candle flow. Only one extremity is ever involved in any individual, which suggested to Putti the name "osteosis eburnisans monomelica".

The clinical picture is not nearly so definite as the roentgenographic findings which really establish the diagnosis. The symptoms are indefinite and vague and serve chiefly to lead the physician to examine the skeleton roentgenographically.

Nineteen cases have been reported to date [2]; some were recorded as unidentified conditions, but they are now recognized under this classification. Eleven of the patients were males, the ages ranging from eight to fifty-four years. The right side was affected in twelve cases, and the upper extremity in the same number of cases.

The following case which has come under the observation of the authors is interesting because of its singular association with scleroderma superimposed upon the area affected in the bone and covering the same general pattern.

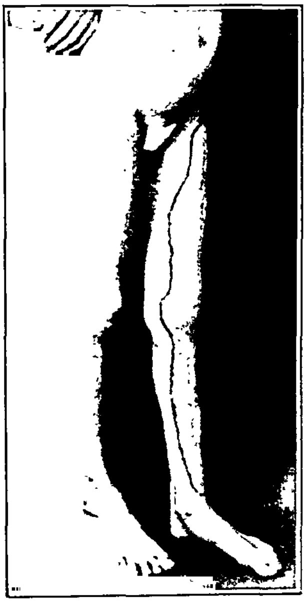

Fig. 1-A

Patient on admission.

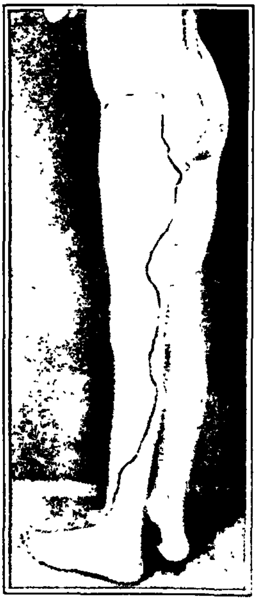

Fig. 1-B

Area outlined is the delimitation of scleroderma.

Fig. 2

Roentgenographic appearance of the pelvis and left femur, revealing hyperostotic flow in the ilium and a suggestion of cystic changes in the femur.

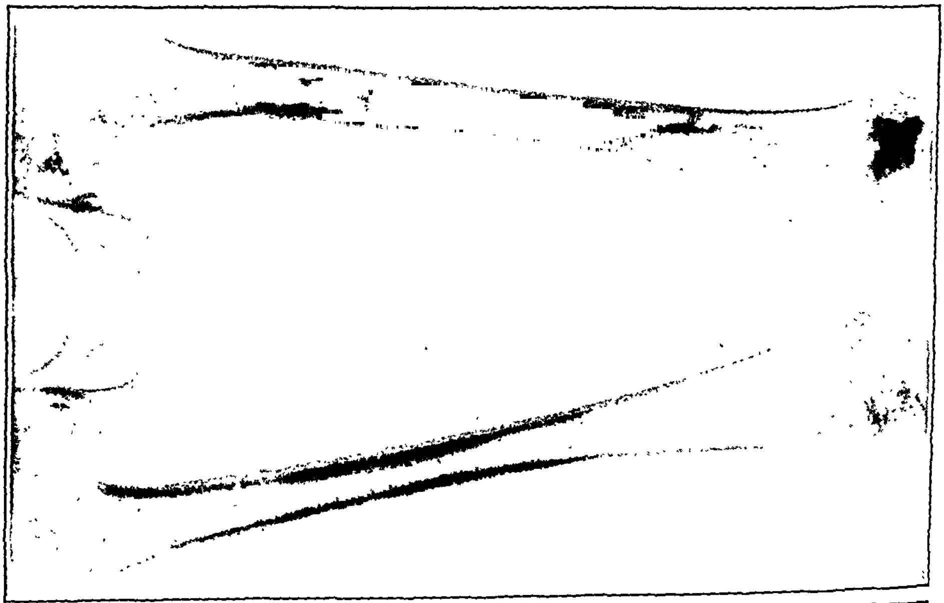

Fig. 3

Hyperostotic flow in the femur.

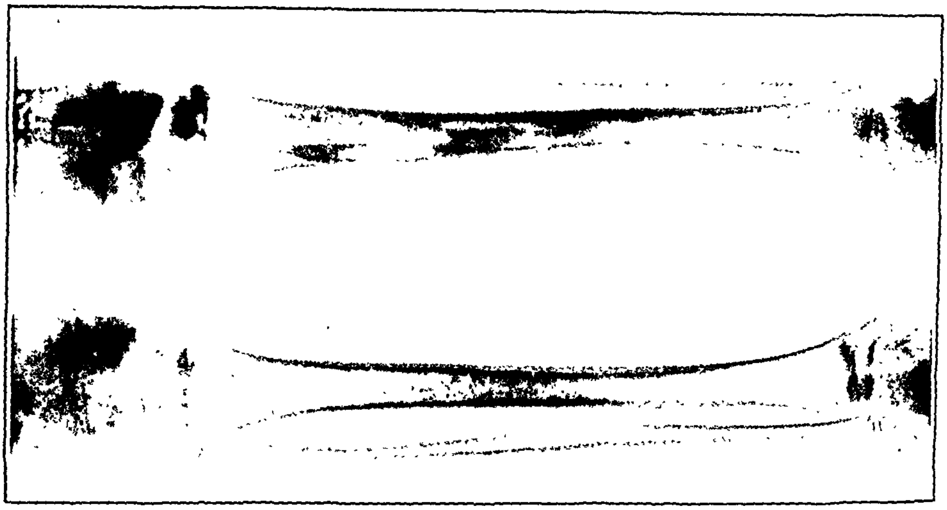

Fig. 4

Roentgenographic appearance of the tibia.

CASE REPORT

F. H., a white boy, ten years of age, entered the hospital on April 26, 1934, because of deformity of the left leg. He had been a full-term baby; the delivery had been uneventful; and infancy had been normal. When the patient was about six months of age a nurse had noticed that the left thigh was "hard", and soon afterward the left leg had become hard also. The condition affected the lateral aspect only. Between the ages of one and two years, this area had become "whiter", and at about five years the skin had become rough. Neither the boy nor the parents could remember exactly when the other symptoms had developed, but it seemed that he had always limped a little, and the mother thought "this was because his knee was stiff". A short time prior to hospitalization the patient had accidentally struck himself on the left thigh with a baseball bat; there had been no previous injury. After this accident, he complained of pain for the first time, crying that night and often thereafter. The mother said he "acted like a person with a cramp in his leg". He was taken to a local doctor who discovered the left lower extremity to be one inch shorter than the right; the parents and the boy had not been aware of this. On writing to the hospital one month later, this doctor said that the boy "is just recovering from an attack of acute lameness and pain in the left hip and knee accompanied by fever". Traction had been applied at home with relief; its removal always resulted in a return of the pain. The school teacher later told the mother that the boy had been crying with pain off and on all winter.

The physical examination was essentially negative except for the left lower extremity and a degree of malnourishment. Notes made on admission state: "There seems to be some pathology with reference to the left hip which discloses limitation of movement in all directions. There is thickening of the skin and subcutaneous tissue extending from the anterior superior spine of the ilium down to the foot, which restricts flexion of the knee (Figs. 1-A and 1-B). There is no complaint of pain on movement of the joints. Roentgenograms of the skeleton disclose radiating sclerotic bone shadows of the left ilium and a similar shadow at the head of the femur, and combination of cystic-appearing

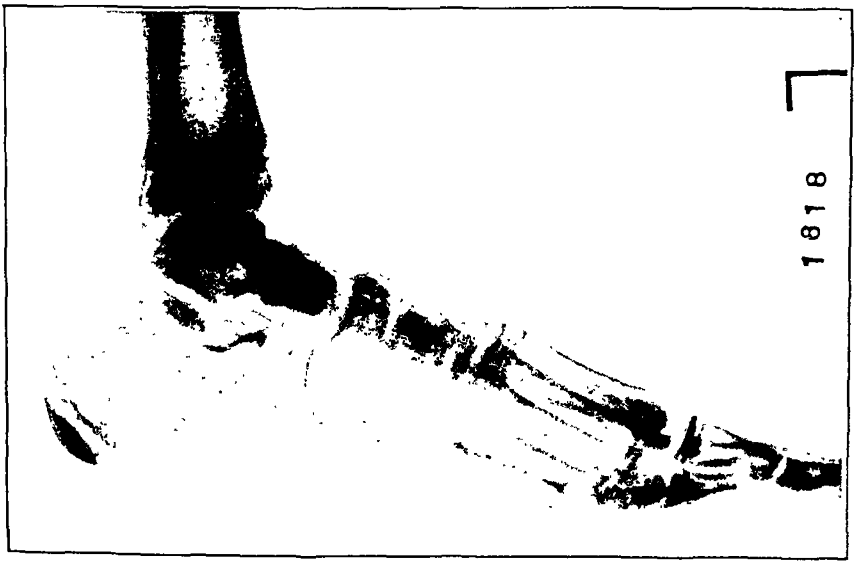

FIG. 5

Showing extension of ostotic flow into the astragalus, scaphoid, and metatarsals.

known symptoms is placed at six months of age. The wide-spread scleroderma present in this case has not been hitherto reported and is particularly interesting in that the sclerotic area of the skin is directly superimposed over the sclerotic area of bone. The report of fever following the injury might be interpreted as giving support to the theory of an infectious process. *Shortening, not often noted, was present.* In this case, unlike those hitherto reported, there seem to be associated lesions in the upper end of the femur which suggest the appearance of osteitis fibrosa cystica.

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TREATMENT OF INTERCONDYLAR FRACTURES OF THE ELBOW BY MEANS OF TRACTION *

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Of all the fractures occurring in or around the elbow joint there are none that offer such perplexing problems of treatment as intercondylar fractures. Fortunately they are rare, for, despite careful treatment, most cases end in complete ankylosis of the elbow joint. In a recent paper, read before the American Academy of Orthopaedic Surgeons, James S. Speed emphasized the problems that confront the surgeon in dealing with this type of fracture which receives but scant attention in text-books on fractures.

The cause of intercondylar fracture is direct violence either from a fall or from a direct blow over the tip of the olecranon. If the force strikes obliquely either the capitulum, or the articulation for the head of the radius, or the trochlea, the articulation for the trochlear portion of the ulna is fractured and the elbow joint is completely disorganized in consequence. Worse still, when both articular areas are fractured the proximal end of the shaft of the humerus is wedged in between the fragments and may be forced into the elbow joint.

Inasmuch as muscle contraction is the direct cause of deformity in fractures of the long bones, one can readily appreciate that the most bizarre deformities must follow intercondylar fractures of the elbow because of the complex muscle attachments around the joint. Contraction of the triceps muscle posteriorly and of the biceps and brachialis anticus anteriorly is the chief cause of deformity following fractures which penetrate the elbow joint. In addition, the attachment of the pronators and flexors on the trochlea and of the supinators and extensors on the capitulum tends to exaggerate the deformity and to enhance the problem of treatment.

Intercondylar fractures of the elbow joint fall into two classes: T fractures and Y fractures. In most T fractures (Figs. 1-A and 1-B) there is a transverse fracture of the lower humeral shaft and a vertical fracture separating the articular areas. The proximal end of the shaft is driven between the articular fragments, completely disorganizing the elbow joint. Even if the distal end of the shaft of the humerus is not forced between the articular fragments, the fragments are driven backward and the angulation results in a dorsal displacement of the elbow joint, due to contraction of the muscles of the upper arm.

The Y fractures of the elbow joint are divided into two groups:

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 19, 1936.

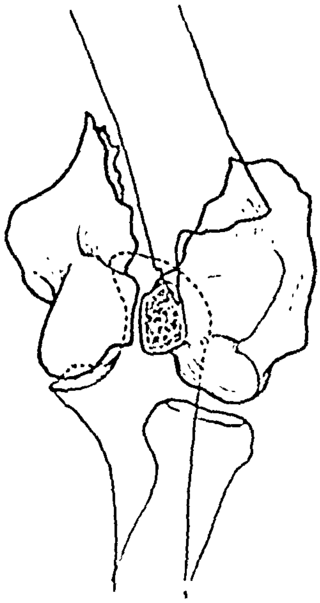

FIG. 1-A

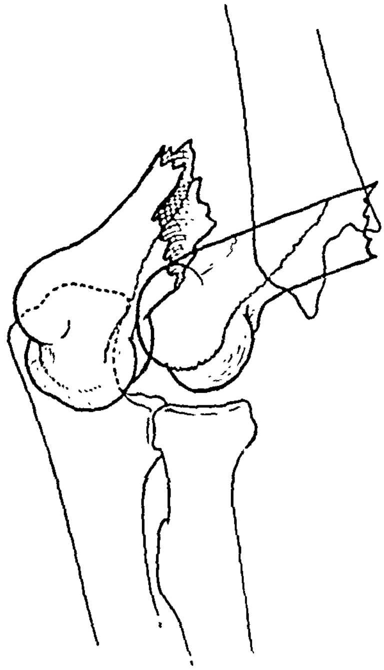

FIG. 1-B

Intercondylar T fracture.

Fig. 1-A: Anteroposterior view. Fig. 1-B: Lateral view.

fractures of the capitulum and fractures of the trochlea. When the capitulum is fractured (Figs. 2-A and 2-B), it is displaced upward and the head of the radius usually accompanies it, the ulna slipping in between the fractured capitulum and the trochlear portion of the articular area. When the trochlea is fractured (Figs. 3-A and 3-B), it is displaced upward, carrying with it the ulna and again disorganizing the elbow joint. In this type of fracture there is very frequently an injury to the ulnar nerve;

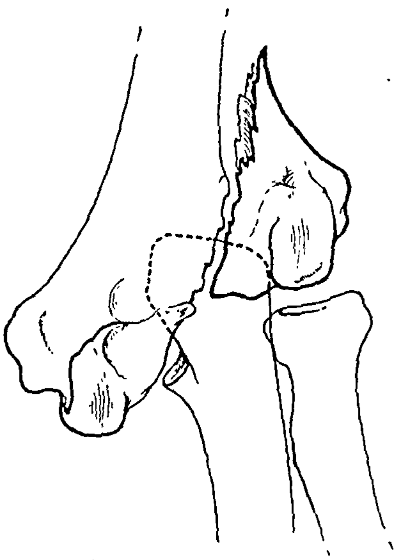

FIG. 2-A

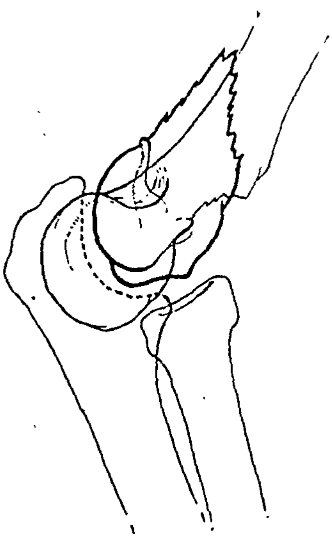

FIG. 2-B

Intercondylar Y fracture, showing splitting off of capitulum.

Fig. 2-A: Anteroposterior view. Fig. 2-B: Lateral view.

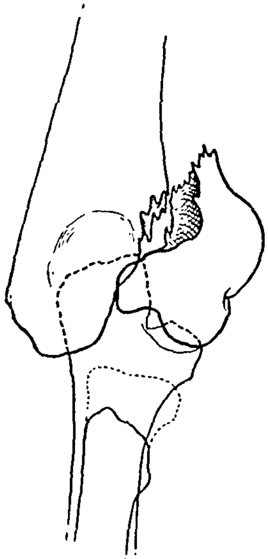

FIG. 3-A

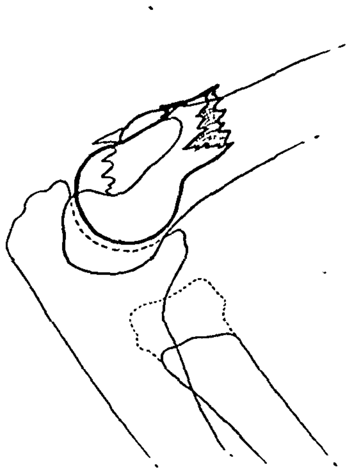

FIG. 3-B

Intercondylar Y fracture, showing splitting off of trochlea.
Fig. 3-A: Anteroposterior view. Fig. 3-B: Lateral view.

hence one must always test the ulnar distribution to determine the extent of the nerve injury.

In the treatment of intercondylar fracture one has no hesitation in recommending open reduction as the only procedure which offers any hope of complete functional restoration. The technique commonly advised is frank exposure of the fragments and the securing of the fractured portion with nails, screws, or bolts. Nevertheless, the results are unsatisfactory. This is undoubtedly due to the difficulty of reducing the fragments displaced by muscular contraction. Moreover, after the fragments have been brought into proper position, it is difficult to retain them by any form of artificial fixation. The foreshortening which results from the overriding of the fragments by the shaft must be corrected before the fragments can be approximated. This is accomplished by traction whereby the articular fragments are pulled into position past the distal end of the shaft and approximated to each other; the distal end of the shaft is then maintained in proper relation to the fragments. Sometimes a Kirschner wire is inserted through the olecranon process of the ulna, or a Kirschner wire or a Steinmann pin is driven through the distal fractured fragments of the humerus in the elbow joint. Even if this procedure does correct the overriding, one still encounters difficulty in properly approximating the articular fragments and in retaining them in proper alignment.

Bearing in mind the difficulties of treatment, the writer employed the following method of correcting a T fracture in which there was complete disorganization of the elbow joint with separation of the articular fragments by the distal portion of the humeral shaft. Old-fashioned ice tongs were employed in the traction. The medial epicondyle was exposed by an incision, two to three centimeters long, on the medial side of the elbow

joint. One prong of the tongs was inserted into the medial epicondyle and the incision was closed. The same procedure was employed on the outer side of the joint, the other prong being inserted into the lateral epicondyle and the tongs secured in place by means of the screw attachment on the tongs. A specially constructed Jones humerus splint (Fig. 4) was applied; the traction portion of the splint was extended downward for a distance of eighteen inches, instead of the two inches which one usually employs in using this splint. The end of the tongs was lashed to the traction end of the Jones humerus splint and the patient was allowed to walk about. Every few hours the tongs were tightened and traction was increased, the position of the fragments being noted by roentgenograms and by the fluoroscope. Should it be necessary to keep the patient recumbent, skeletal traction by means of the tongs can be employed with the aid of a Thomas arm splint (Fig. 5). A hinged right-angle extension with a block extension is attached, so that the position of the elbow joint can be controlled from the forearm while traction is applied.

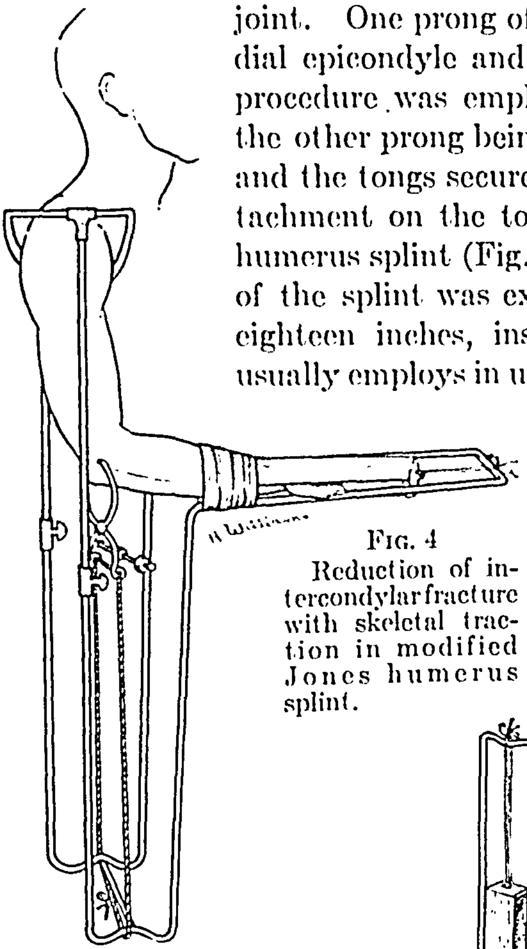

Fig. 4

Fig. 4
Reduction of intercondylar fracture with skeletal traction in modified Jones humerus splint.

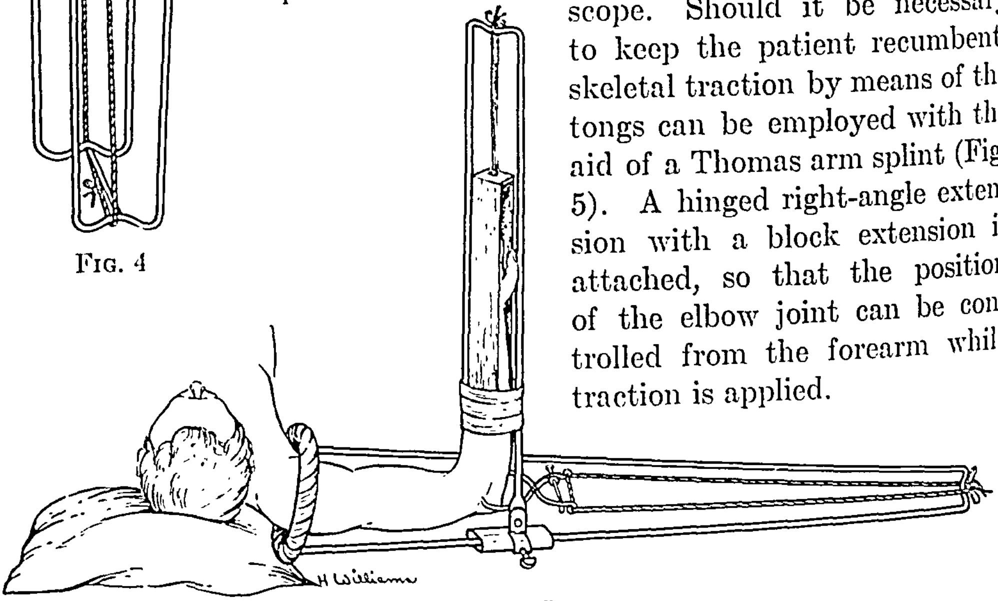

Fig. 5
Treatment of intercondylar fracture with skeletal traction in Thomas arm splint.

In the patients treated, overriding of the articular fragments by the shaft was completely overcome within thirty-six hours and then, by screwing the tongs more tightly, the fragments were approximated and the gap in the humeral articulation was eliminated. The end of the humeral shaft was then adjusted in position and, by means of forward traction on the forearm, the angulation deformity was overcome. This position was maintained by the modified Jones humerus splint for a period of approximately three weeks with very little difficulty, after which frequent roentgenograms showed that sufficient callus had formed to permit the removal of the tongs, but the Jones humerus splint was retained for

another two weeks. The arm was then placed in a sling and active motion was begun.

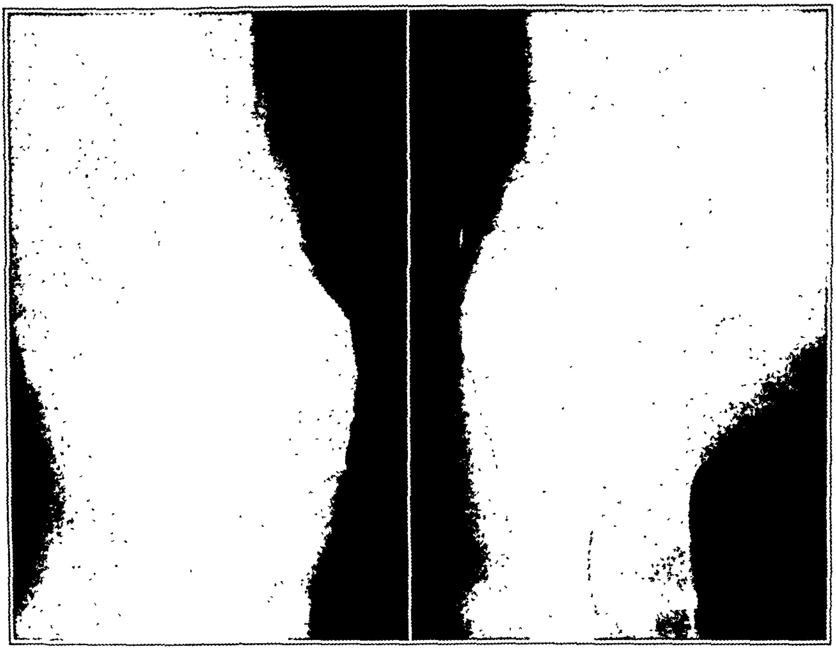

Fig. 6-A
Intercondylar T fracture.

Fig. 6-B
Intercondylar T fracture (lateral view) following skeletal traction.

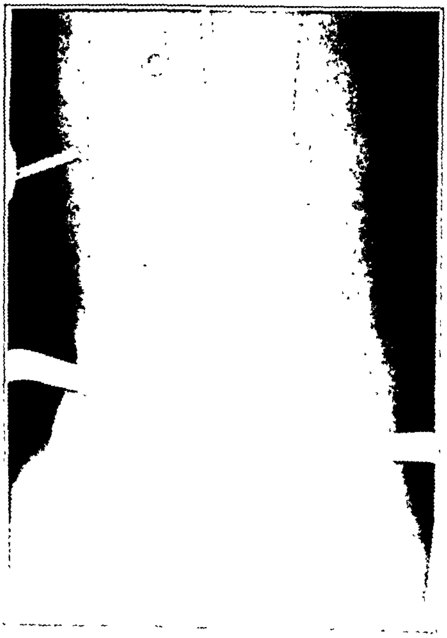

Fig. 6-C
Intercondylar T fracture (anteroposterior view) following skeletal traction.

In treating Y fractures of the elbow, the same method is employed. In the case of a fracture of the trochlea with upward displacement of the

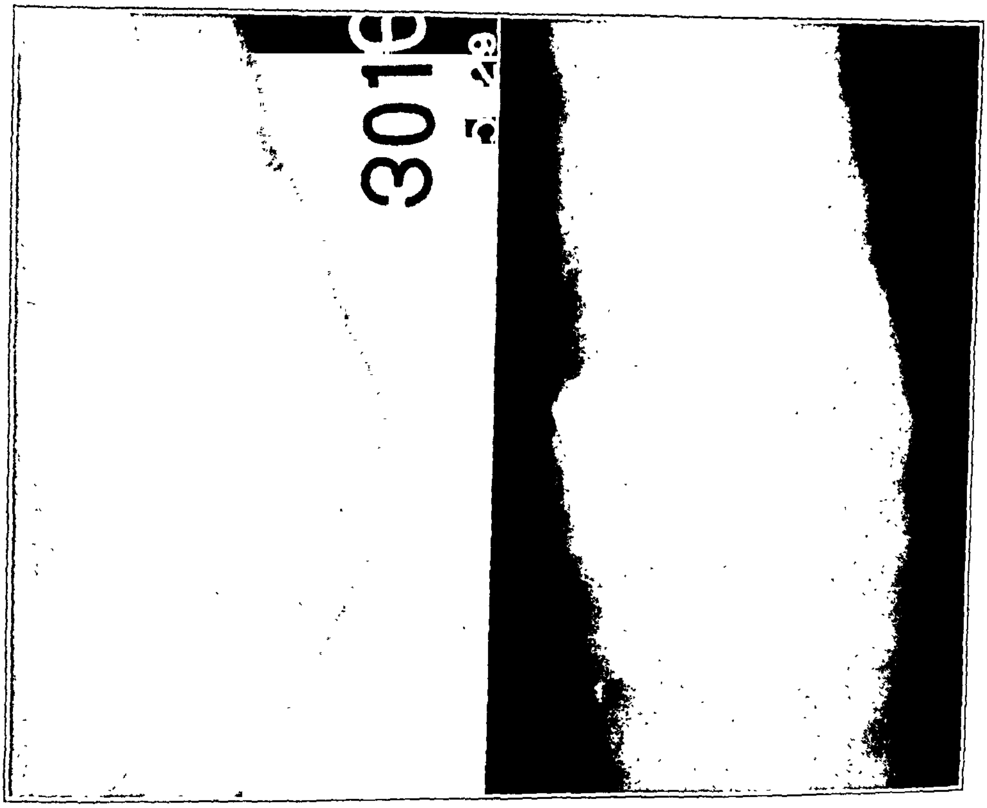

FIG. 6-D

Intercondylar T fracture. End result following skeletal traction.

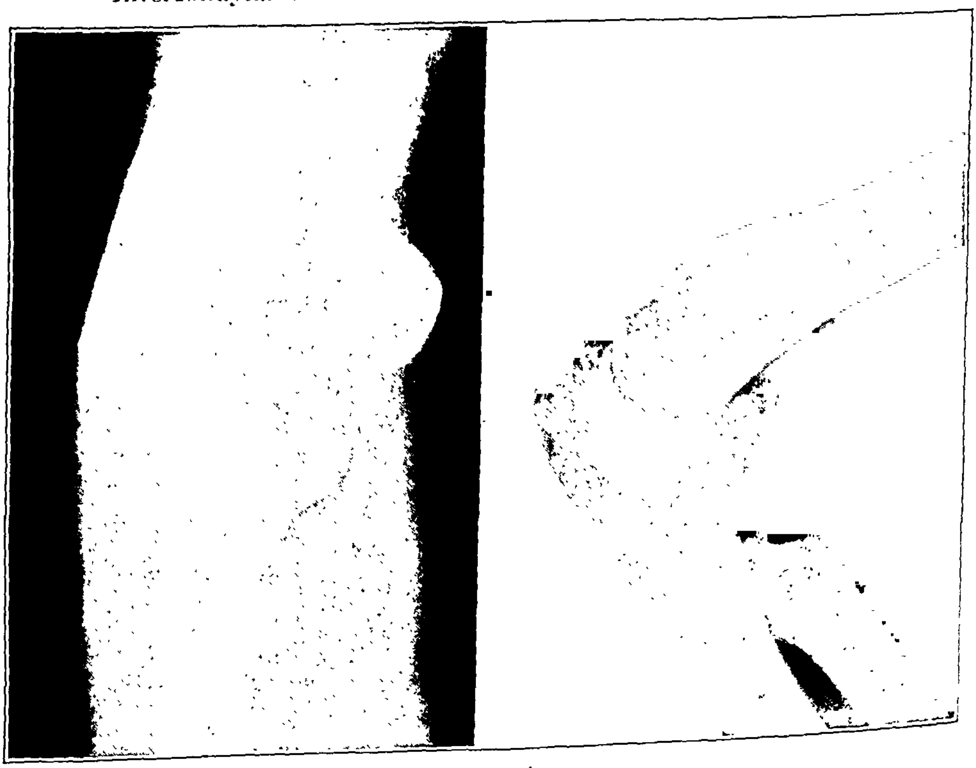

FIG. 7-A

Intercondylar Y fracture of trochlea. (Head of radius removed eight months previously following comminuted fracture.)

medial articular portion of the humerus, one prong of the tongs is inserted into the medial condyle through a small incision which lays bare the epi-

Fig. 7-B

Intercondylar Y fracture of trochlea (lateral view) following skeletal traction.

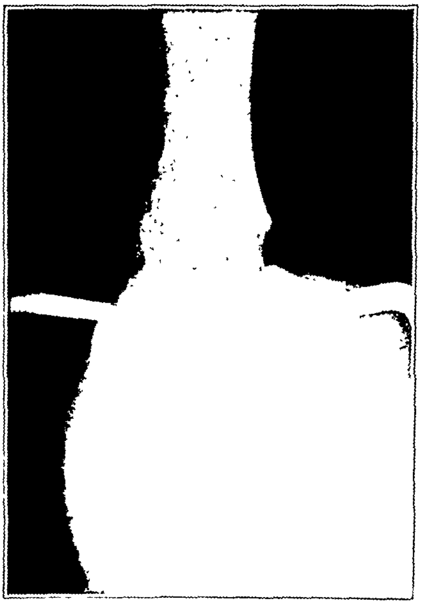

Fig. 7-C

Intercondylar Y fracture of trochlea (anteroposterior view) following skeletal traction.

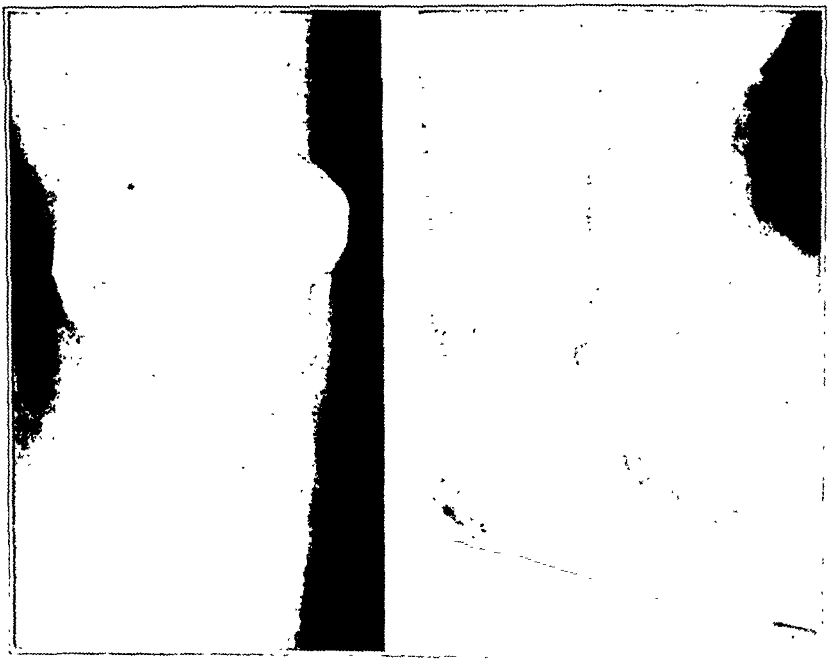

Fig. 7-D

Intercondylar Y fracture of trochlea. End result.

condyle. The other prong is then inserted into the lateral epicondyle in a similar manner. The same type of Jones humerus splint, with unusually long traction attachment, is applied. In this type of fracture, instead of straight downward traction, the tongs are forced toward the lateral trochlear portion of the elbow joint. In this way the displaced fragment is approximated in proper position to the capitulum and is drawn down into proper alignment until sufficient callus has formed to render traction by the tongs superfluous, and later the Jones humerus splint can be removed.

In fractures of the capitulum, with complete upward displacement of the fragment, the same principle is employed. In this, as in the other types of fracture, the tongs are first inserted into the medial epicondyle to avoid injuring the ulnar nerve. The tongs are forced medially until the capitulum has been brought down into proper alignment with the trochlea and the gap in the articular face is closed.

This method of producing traction by ice tongs has been employed in treating six patients, all showing simple fractures. Five of the patients were males. Of these six patients, four presented the T type of intercondylar fracture and two the Y type. The one female patient exhibited a T fracture. Of the two Y fractures, one involved the trochlea and the other the capitulum. Of the six patients, good results were obtained in three; two of these patients had T fractures and the third, a Y fracture. Fair results were obtained in two cases, one of which was a T fracture and the other a Y fracture. In the case of the one female patient, the result was a complete failure, owing to the fact that both articular fragments were so badly comminuted that satisfactory purchase on the epicondyles by the tongs was impossible. In treating this patient the device was abandoned.

COMMENT

Six instances of intercondylar fracture are reported in this paper, together with end results, the object being to suggest a new device in the treatment of a very intractable type of fracture. The recital of end results is merely an incident in the presentation.

None of the fractures treated was compound. In compound fractures the immediate application of ice tongs is contra-indicated. A delay of five to ten days, or until the fracture has been converted into a simple fracture, before skeletal traction is resorted to is most important. As a matter of fact, in all instances of intercondylar fracture there is severe swelling and ecchymosis, and no harm results from deferring application of the tongs until the tissue resistance has been restored. Traction by ice tongs is also contra-indicated in cases where there is such marked comminution of the intercondylar fragments that the prongs do not gain purchase when applied. Infection in or around the elbow joint is obviously also a contra-indication to the use of this method of correction.

Although intercondylar fractures of the femur are not specifically considered, it should be reported that the writer has successfully employed this method of treatment for that type of fracture.

THE SELECTION OF THE ANAESTHETIC IN CASES OF FRACTURE OF THE JAW

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In traumatic injuries to the face, particularly in those which include maxillary fractures, the necessity of immediate surgical procedure frequently has a tendency to relegate the choice of anaesthesia to the realm of pure routine. This circumstance is most unfortunate, for the involved area will almost invariably affect, directly or indirectly, either the alimentary or the respiratory tract or both; therefore, the anaesthetic used must be one that will cause the least embarrassment to the normal functioning of these tracts. It should be remembered, too, that the anaesthetic must offer complete effectiveness during the operation, but must avoid, to the greatest extent possible, additional discomfort and suffering on the part of the patient. A stormy postanaesthetic period will greatly impede recovery.

As pertinent to the choosing of an anaesthetic, Lundy enumerates the following factors:

1. The patient's mental and physical condition;
2. The proposed operation;
3. The technique of the surgeon;
4. The requisite of anaesthesia or of analgesia;
5. The necessity for relaxation;
6. The need of quiet breathing;
7. The quick recovery of reflexes;
8. The likelihood of the production of immediate or delayed untoward results.

In cases where the mandible has been fractured and immobilization by wiring is indicated, considerable controversy has arisen over the question of wiring the jaws while the patient is under a general anaesthetic. Among others in favor of this method is Hensel who cites a series of eighteen cases of immediate fixation of the mandible under general anaesthesia in which no complications from vomiting occurred. He states that the depth of the anaesthesia need not be great. Since in general anaesthesia there are usually three recognized stages—a primary (analgesic) stage, a secondary (excitement) stage, and a third (surgical) stage—it is assumed that he refers to one of the first two.

The author's own experience with wiring the jaws while the patient is anaesthetized and unconscious, however, has not recommended the continued use of this method. In a number of instances where the jaws were immobilized with the patients under a general anaesthetic it was very difficult to obtain and maintain satisfactory occlusion. In addition

to the usual difficulties encountered, there were three cases of near fatalities,—two patients swallowed their tongues and a third developed pneumonia. Where conditions indicate general anaesthesia, and immobilization by wiring is the chosen method of fixation, the writer considers it feasible to place the eyelet wires in their respective positions, but advisable to refrain from completing intermaxillary fixation until the patient has regained consciousness and has recovered fully from the effects of the anaesthetic.

In uncomplicated fracture cases where there has been no untoward elapse of time, the author prefers local anaesthesia. The best results have been obtained with pre-anaesthetic medication and a few drops of a 1-per-cent. solution of novocain injected high in the mucobuccal fold in the region of operative activity. This utilization of local infiltration, beside being completely adequate, provides most essential and efficient cooperative measures. It leaves the patient free to shift his position at will, thereby permitting him to assist in supplying countertraction when needed. Of even greater importance is the necessity of complete muscular relaxation in securing good alignment of the fragments. This may be achieved with intramuscular injections of novocain to a degree equalled by ether administration only in a state of complete narcosis, a condition scarcely warranted by the type of operation.

It is conceded that the employment of general anaesthesia is necessitated under certain circumstances. In fracture cases where the initial treatment has been delayed until fibrous union has taken place, or where extensive surgery of the bone and soft tissues is required, general anaesthesia is the method not only of choice but of necessity. Similarly, local anaesthesia is definitely contra-indicated in the case in which infection has already occurred, for there is the serious possibility of carrying the infection into the deeper soft-tissue structures and also of endangering the bone itself. In these instances the writer has made use of ether, rectal avertin, and a combination of avertin with novocain. Of the first two, it is the author's opinion that the rectal avertin is unquestionably superior, primarily because of the following facts:

1. The anaesthetist is out of the operative field;
2. Respiration is regular and normal;
3. Reduction is accomplished without untoward results which follow the use of an inhalation anaesthetic;
4. There is early relaxation of the muscles of the jaws and tongue;
5. The supplemental employment of an inhalation anaesthetic is avoided;
6. The dangers of explosion connected with the use of the cautery are obviated.

When ether is to be used, the condition of the patient must be considered carefully both before its administration and during the period of recovery from its use. Especially in cases where the operative field is the jaw, the possibility of postoperative vomiting and its effects may not be

dismissed lightly. Some operators insist upon the complete emptying and washing of the stomach before the ether is given. This precaution, while of undoubted value systemically, will almost certainly bring about a mental state approaching hysteria in the person already suffering from shock. The reaction most frequently found is the fear of "dying under the ether". While the patient's mental attitude before the operation is deserving of sympathetic consideration, the surgeon must weigh carefully the numerous factors which are going to influence both the progress and the results of his surgery if it is to be undertaken in conjunction with an inhalation anaesthetic. For his own part, he is fully aware of the difficulties of working over a mouth from which ether vapor is being given off.

Among the items of direct significance in regard to the patient are:

1. Possible asphyxia and suffocation caused by the swallowing of the tongue, or by the mouth and stomach secretions in the respiratory tract;
2. Greatly increased salivary secretion;
3. Possibility of cyanosis produced by faulty position of the head;
4. Effect of cough reflex on aspiration, gagging, etc.;
5. Postoperative shock and fatigue;
6. Danger of pneumonia;
7. Impossibility of confining effects of anaesthesia to regional parts;
8. The extended time factor in recovery caused largely by effects and consequences of postoperative vomiting. Not only is the systemic reaction to ether involved, but the retching and struggling with the jaws immobilized may necessitate the immediate cutting of the tie wires. Also, this involuntary strain creates a grave possibility of displacing fragments and of loosening fixation which otherwise would have permitted normal union.

Of importance from the standpoint of the hospital are the increased costs of operating under general anaesthesia, the greater risk of fatalities, and the greater amount of postoperative nursing care required. In connection with this last item, experience has convinced the writer that it is essential to maintain constant nursing care until the patient has fully recovered consciousness.

CONCLUSIONS

In uncomplicated fractures of the jaw, local anaesthesia has been found to be completely adequate. At the same time, it offers distinct advantages over general anaesthesia. The negative factors common to the use of a general anaesthetic, particularly when of the inhalation type, are eliminated. It is recognized, however, that serious and involved conditions, including the presence of infection, will necessitate the use of general anaesthesia. In these cases the author's preference is rectal avertin.

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SACRARTHROGENETIC TELALGIA

IV. Differential Diagnosis in Sacrarthrogenetic Scoliosis

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This article is the fourth of a series of five.* It is based upon further statistical analyses of the 650 records used in the second article. Its scope is limited to a study of sacrarthrogenetic scoliosis, and its purpose is to show that the pattern of the scoliosis is a valuable guide to a better understanding of the pathological changes that occur in the upper sacral joints.

In beginning the statistical study, we eliminated all cases in which there was a measurable inequality in the length of the lower extremities and those in which there were obvious structural derangements, either in the internal balance or in the external muscular support of the presacral vertebral column. We next subjected eighty items of positive or negative evidence noted in the physical examination of each case to the scrutiny of statistical machinery, ** each item being compared with every other item in an attempt to determine any primary fixed relationships among them. Many tendencies were noted, but no fixed rules could be discovered by this method. Three items in this study deserve mention:

1. In reviewing the literature, we found a general impression that the trunk lists away from the side of the chief complaint in approximately 60.0 per cent. of cases. In each of our cases, the list was determined with a plumb-line, and the figures are: heterolateral list, 45.0 per cent.; homolateral list, 47.0 per cent.; no list, 8.0 per cent. We noted, however, that spectacularly large excursions tended to appear more frequently in the heterolateral list,—a condition that may cause the observer to accord numerical superiority to the deviation which more often arrests his attention.

2. Relaxation of the gluteal muscles, lowering of the buttock, and subsequent atrophy of the buttock have been noted in cases that showed sacrarthrogenetic telalgia. In each of our cases the relative height of the inferior margins of the buttocks was determined with a spirit-level. In 55.0 per cent. of our cases there was a lowering of the gluteal fold on the side of the chief complaint; the relationship was heterolateral in 28.0 per cent., and the buttocks were level in 17.0 per cent. In other words, if the level of the buttocks is unequal, the chances are approximately 2 to 1 that the lower buttock is on the side of the chief complaint.

* Three articles have been published under the same title.[2] The fifth is now in preparation and will deal with the treatment of cases in which sacrarthrogenetic telalgia is present.

** For the use of this equipment we are indebted to the Powers Division of the Remington-Rand Company.

3. In each of our cases the relative height of the shoulders was determined with a spirit-level. The figures for the relationship of the lower shoulder to dorsal scoliosis are: heterolateral relationship, 80.0 per cent.; scoliosis present, but shoulders level, 3.0 per cent.; scoliosis absent, but shoulders not level, 9.0 per cent.; homolateral relationship, 8.0 per cent. Thus, if the level of the shoulders is unequal, the chances are almost 10 to 1 that a dorsal scoliosis is present. Furthermore, if a dorsal scoliosis is present, the chances are 10 to 1 that the convexity of the curve is on the same side as the higher shoulder. These facts have been noted many times in the literature, but we repeat them because they are of value in the determination of doubtful curves.

In our next investigation, we combined groups of two or more items that showed definite numerical relationships and subjected these groups to comparative study in the statistical machines. These studies produced figures of 90.0 per cent., and upward, to justify the following three conclusions:

1. In normal subjects, the production of any type of scoliosis by voluntary muscular effort regularly is accompanied by pelvic torsion.* This torsion is associated with a tilting of the sacrum toward the ilium that shows the smaller angle of inclination, and toward the apex of the lateral curve of the lumbar spine. More simply stated: right or left pelvic torsion normally is associated with a homolateral curve of the lumbar spine.

2. In normal subjects, the reflex muscular response initiated by an experimental lengthening of one lower extremity reverses this relationship, apparently in an attempt to correct the fixed lumbar curve.** Under these conditions, right or left pelvic torsion is associated with a heterolateral curve of the lumbar spine.

3. In sacrarthrogenetic scoliosis, either of the above relationships of lumbar curve to pelvic torsion may be present in the habitual stance. The heterolateral relationship, however, regularly is associated with many other evidences of a disturbance in the function of the upper sacral joints.

Thus, in normal sacro-iliac function, we see that the lumbar curve always reflects the tilt of the sacrum which, in turn, reflects the pelvic torsion. If one alters the factor of sacral position (in relation to the constant plane of the horizon) and produces an abnormal lateral tilt by experimentally lengthening one lower extremity, the lumbar curve reflects the abnormal sacral tilt, but it does not reflect the pelvic torsion. If the factor of pelvic torsion is altered by abnormal iliac mobility, such as was shown by the case reported in the third article of this series, the lumbar

* For the sake of brevity, we use the term "pelvic torsion" to indicate antagonistic motion of the two ilia about a horizontal transverse axis that passes through the symphysis pubis. "Right torsion" indicates that the right ilium shows a smaller angle of inclination than the left, and *vice versa*.

** A detailed description of the changes produced by experimentally lengthening one lower extremity was presented in the second article of this series.

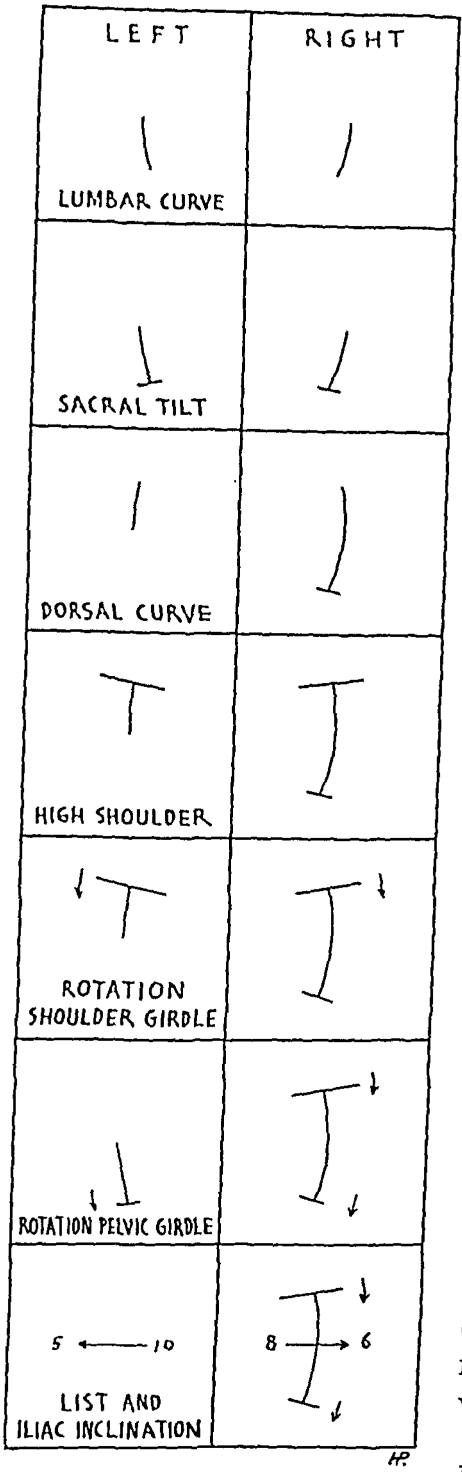

FIG. 1

FIG. 1

A simple method of measuring and recording sacrarthrogenetic scoliosis.

The author suggests the following routine procedure: Request the subject to stand "at ease" with the hands at the sides and with the unshod feet about three inches apart. Expose the entire back and the lower extremities. Palpate and *mark out* the dorsal, lumbar, and sacral spinous processes. Record the lumbar and dorsal curves just as they appear from the marks on the back. Note and record the tilt of the sacrum and, if it differs from the lumbar curve, recheck the markings of both. (In our experience, the failure of the two to coincide indicates a sacrolumbar disturbance.) Note and record the level of the shoulders and, if the high shoulder is not on the same side as the convexity of the dorsal curve, recheck the marking of the latter. (In our experience, the chances are 10 to 1 that the high shoulder will coincide with the dorsal convexity.) To measure the rotation of the shoulder girdle, place a ruler or other straight edge upon the floor in contact with the subject's heels; take one end of a three-foot tape or string in each hand and, holding it taut and horizontal, bring it into light contact with the skin over the spines of the subject's scapulae; sight downward across the tape and compare its position with that of the ruler on the floor. Record the shoulder that tends to be rotated backward behind the plane of the heels. The rotation of the pelvic girdle is measured and recorded in a similar manner, except that the tape is held in contact with the most prominent portions of the buttocks. If marked atrophy of one or both buttocks makes these landmarks unreliable, the tape may be held behind and parallel to a line joining the posterior superior iliac spines. Measure the list by dropping a plumb-line through the intergluteal fold. If the spinous process of the seventh cervical vertebra (vertebra prominens) lies completely to one side of the plumb-line, record a list to that side. (Frequently, a lateral shift of the pelvis is present, as indicated by the fact that the plumb-line does not fall midway between the heels. This shift may be recorded by a horizontal arrow placed below the rest of the pattern.) The iliac inclination is measured with an inclinometer and is recorded in degrees on the appropriate side of the pattern.

curve still reflects the sacral tilt, but it does not reflect the pelvic torsion. Therefore, we may state our first two diagnostic rules:

1. *If the lumbar spine is normal, the lumbar curve reflects the position of the sacrum.* It will be noted that this rule applies, not only to a lateral tilt, but also to the forward tilt of the sacrum which is reflected in the lumbar lordosis.

2. *If the lumbar spine is normal, and if the lower extremities are equal in length, the lumbar curve normally reflects the pelvic torsion. A reversal of this relation indicates abnormal mobility of the sacro-iliac joints.*

In all of our cases of sacrarthrogenetic scoliosis, we have recorded certain findings at each examination in the form of a simple diagram.

The method is shown in Figure 1. These diagrams are convenient, not only in checking the progress of a single subject, but also in grouping records that show like patterns of scoliosis. If one arbitrarily selects left-lumbar scoliosis as a constant and combines it with the four variables—dorsal scoliosis, rotation of the shoulder girdle, rotation of the pelvic girdle, and list of the trunk—sixteen combinations are produced. (See Figure 2.) The sixteen combinations of right-lumbar scoliosis with the same four variables are, of course, mirror-images of the left-lumbar patterns. By reversing all of the findings in cases that showed a right-lumbar curve, we grouped our records into the sixteen patterns illustrated in Figure 2, and continued the statistical study of the individual groups.

This study immediately focused our attention upon two patterns of

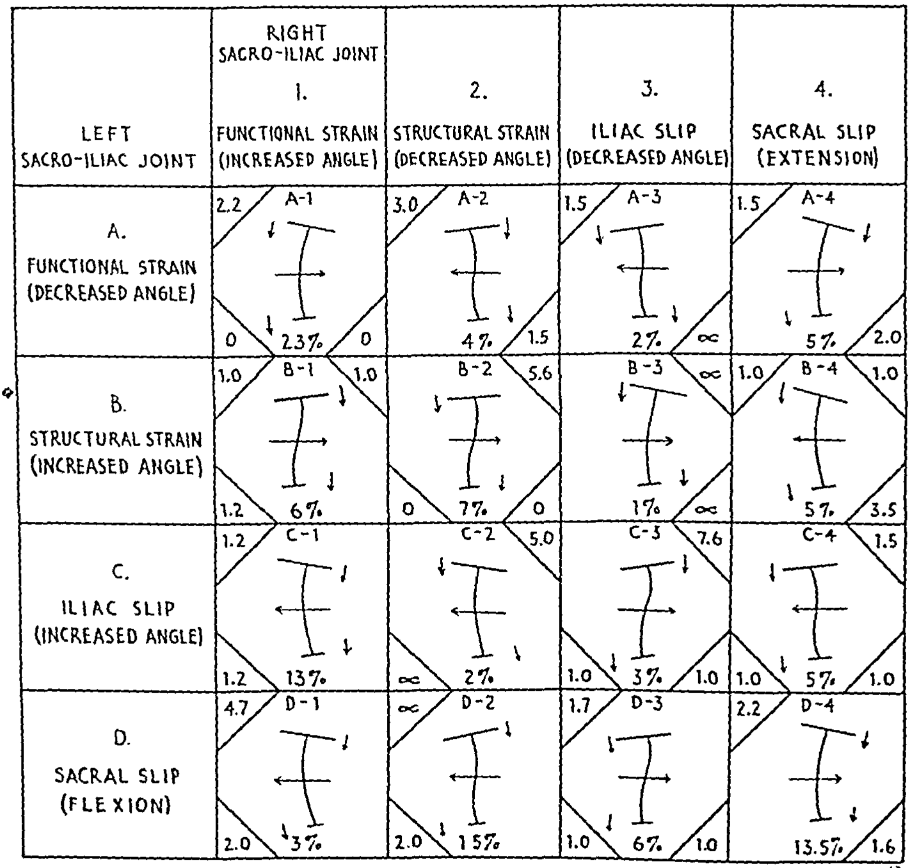

FIG. 2

Left-lumbar sacrarthrogenetic scoliosis. The figure beneath each pattern indicates the incidence per cent. of that pattern in this series. The figure in the upper corner of each frame shows the chances (related to unity) that prevailed in this series of finding the named pelvic torsion on the side indicated. The figure in the lower corner of each frame shows the chances of altering the pattern by manipulative rotation of the pelvis toward the indicated side and will be discussed in the final article of this series. The sixteen patterns of right-lumbar sacrarthrogenetic scoliosis are mirror-images of the left-lumbar patterns (*1-A*, *2-B*, *3-C*, *4-D*, etc.).

scoliosis (Fig. 2, *A-1* and *B-2*). "Transitional scoliosis" is the term used to describe the single curve that shows a rotation toward the convex side,[1] but we have not found in the literature any name for the double scoliosis that shows a rotation toward the *concavity* of each curve. Since these two patterns in our series have shown the same fundamental significance, we feel that they should bear in common the title by which the single curve already is known, and that they should be designated as "single" and "double" transitional scoliosis.

We make a practice of gently manipulating the spine and sacral joints as a part of our routine physical examination. Whenever sounds are obtained that seem to indicate a sudden alteration in the position of the upper sacral joints,* we immediately reexamine the subject in the standing position and record any change in the pattern of the scoliosis, as well as the direction of the manipulation that produced the sounds. The same procedure is followed in therapeutic manipulations, unless an anaesthetic has been used that prohibits the assumption of the erect position. Our figures show that manipulation frequently changes other types of scoliosis into one of the transitional patterns, but a reversal of this phenomenon never has occurred. Moreover, when manipulation of any type of sacrarthrogenetic scoliosis initiates a rapid and uneventful recovery, the first examination after manipulation regularly shows a transitional pattern or an incomplete pattern. Finally, three types of subjects show transitional scoliosis with great regularity:

1. Normal individuals who are in the act of performing lateral bending or rotation of the trunk;
2. Patients who show an early stage of acute (specific or non-specific) arthritis of the spinal or upper sacral joints;
3. Patients who show acute, uncomplicated sprains or strains of the pelvic or spinal muscles.

Unequal (voluntary or reflex) action of the muscles that control the spine and the upper sacral joints is the obvious common denominator in these three groups. On the basis of these observations, we may state a third diagnostic rule:

3. Transitional sacrarthrogenetic scoliosis reflects the presence of unequal, reflex, muscular action and denies the presence of a sacro-iliac slip.

In any joint, a dislocation (or a subluxation) consists of a fixed pathological position and a sprain. Restoration of the normal relationship of the joint surfaces reduces the injury to the status of a simple sprain, plus a variable amount of traumatic arthritis. A sprain (or a strain) initiates painful stimuli which travel centrally in the nerves that supply the injured ligaments. These stimuli may cause telalgia, if they affect spinal segments other than the ones that correspond to the derma-

* Sounds of sacro-iliac origin, in our experience, characteristically are low in pitch, possess a muffled resonance, and seem to come from within the deeper portions of the pelvis, as if the bony ring acted as a sounding-board. Sounds that originate in the sacrolumbar and other spinal joints usually are higher in pitch, sharper, and more superficial.

tomes that cover the injured joint, but they invariably initiate reflex muscular action. Reflex spasm results in certain "protective" attitudes. In 404 (100.0 per cent.) of our patients who complained of sacrarthrogenetic telalgia, a complete scoliotic pattern was present as a part of the protective attitude. Of the 506 records used in our "abnormal group", 468 (92.0 per cent.) showed a complete scoliotic pattern.* A pattern was considered to be incomplete if any one of the four fundamental variables (lumbar curve, list, rotation of the shoulder girdle, and rotation of the pelvic girdle) was absent. Of the 144 college entrants in the "normal" group, 120 (83.0 per cent.) showed incomplete patterns in normal stance.

In the sixteen patterns illustrated in Figure 2, left-lumbar scoliosis is a constant, and it follows from our first rule that the direction of the lateral tilt of the sacrum also is a constant. Therefore, the position of the sacrum in relation to the two ilia is reflected in the inclinometric measurements of the variable pelvic torsion, provided that the symphysis pubis is intact. In the single transitional pattern (Fig. 2, *A-1*), our measurements show: left torsion, 35.0 per cent.; torsion less than 2 degrees, 49.0 per cent.; right torsion, 16.0 per cent. In other words, the chances are 2.2 to 1 that, if torsion is present, the normal condition of a homolateral lumbar curve will prevail. By applying our second rule to this pattern, it appears that the sacrum tends to maintain its normal relationship with the ilia, and the structural integrity of the sacro-iliac joints usually is preserved. Therefore, we may state a corollary to our third rule:

3-a. If the lumbar spine is normal, the single pattern tends to appear when function alone is disturbed.

The opposite condition was found in the double transitional pattern (Fig. 2, *B-2*), in which the figures are: left torsion, 9.0 per cent.; torsion less than 2 degrees, 41.0 per cent.; right torsion, 50.0 per cent. In this pattern, the chances are 5.6 to 1 that, if torsion is present, the abnormal condition of a heterolateral lumbar curve will prevail. By applying our second rule, we see that the failure of the sacrum to follow the motion of the ilia is a measure of the structural inadequacy of the sacro-iliac ligaments. Therefore, the second corollary to our third rule is:

3-b. The double pattern tends to appear when both structure and function are disturbed.

The case of alternating scoliosis which we reported in the third article of this series clearly showed the changes that occur in the relative positions of the sacrum and the ilia as the result of iliac slips. The fixed, abnormal position, together with the reflex action of the pelvic and spinal muscles, resulted in a "structural" pattern of scoliosis (Fig. 2, *C-3*). The figures in our series verify the findings in that case and show: left torsion, 8.0 per cent.; torsion less than 2 degrees, 31.0 per cent.; right tor-

* Twenty-six triple curves, four quadruple curves, and one quintuple curve are not included in this number.

sion, 61.0 per cent. The chances are 7.6 to 1, in the structural pattern, that the torsion will not be reflected in the lumbar curve. This evidence of a structural disturbance in the sacro-iliac joints indicates that the accepted term "structural scoliosis" applies to the sacrum and to the presacral spine with equal accuracy. Our fourth diagnostic rule is:

4. Structural, sacrarthrogenetic scoliosis is produced by an iliac slip.

If one excepts the single transitional pattern, the scoliosis most frequently encountered in our series is the "functional" curve (Fig. 2, *D-4*). Unlike the functional scoliosis produced by a short leg, the sacrarthrogenetic pattern tends to show the normal conjunction of pelvic torsion with a homolateral lumbar curve. The figures are: left torsion, 37.0 per cent.; torsion less than 2 degrees, 46.0 per cent.; right torsion, 17.0 per cent. Our manipulative work regularly shows that the sacrum and the ilia are abnormally fixed in this apparently normal position. Mirror-images of this pattern never have been seen in one subject, but careful roentgenographic measurements of many subjects have demonstrated the mechanism of production.* In this pattern, the structural integrity of the sacro-iliac joints tends to be preserved. The sacrum tends to follow the normal motions of the ilia. At some point in the arc of the iliac excursion, usually at one extreme of normal motion, the sacrum moves about its own transverse axis, slips, and locks the joint. The excursion of the sacral slip usually is too small to alter the relations of the sacro-iliac articulation in a measurable degree, and the figures show that the chances are 2.2 to 1 in favor of the normal relationship of torsion to lumbar curve. Thus, we see that the accepted term "functional scoliosis" retains its significance in the sacrarthrogenetic pattern. Our fifth diagnostic rule is:

5. Functional, sacrarthrogenetic scoliosis is produced by a sacral slip.

The four "primary" patterns (the two transitional, the structural, and the functional) constitute 46.5 per cent. of the 468 records of scoliosis in our series. Each of the remaining twelve patterns has been observed in at least five instances (1.0 per cent.). Each pattern has been given a position in Figure 2 in accordance with the recorded pelvic torsion and the direction of the manipulation that altered the pattern. It seems to us unnecessary to name each of these patterns, or to describe each of them separately, since they represent varying combinations of the etiological factors that we have noted in our study of the four primary patterns. Therefore, we shall group them under the generic title of "secondary" patterns.

Patterns *B-1* and *A-2* deserve special consideration. Although they are produced by the same disturbances of structure and of function that are found in the transitional curves, manipulation shows that *B-1* and *A-2* differ from the transitional patterns (*A-1* and *B-2*) in reflecting a fixed pathological position. The reason for this difference becomes apparent when we note that the inclination of both ilia *increases* in *B-1* and

* This was discussed in the second article of this series.

decreases in *A-2*. In other words, the motions of the two ilia in each pattern are agonistic. Agonistic iliac motion in the normal subject produces flexion and extension of the pelvis about the hip joints and is reflected in an increased or a decreased lumbar lordosis, but it does not cause scoliosis. Since it does not reflect antagonistic iliac motion, the lateral curve of the lumbar spine in *B-1* and *A-2* reflects a pathological sacral tilt. However, we have seen, in the study of normal subjects, that reflex action tends to compensate for a tilted sacrum by producing antagonistic iliac motion. Thus, if both sacro-iliac joints were freely movable, the pathological sacral tilt would excite reflex pelvic torsion, and pelvic torsion would transform *B-1* and *A-2* into transitional patterns (the type being dependent upon the relative prominence of the functional and the structural elements in the disturbance of the two sacro-iliac joints). Therefore, a fixed position of the sacrum is necessary in the production of *B-1* or *A-2*. Our experience indicates that these two patterns tend to appear most frequently in cases where the effects of a recent strain in one sacro-iliac joint have been superimposed upon the presence of an ancient slip in the opposite joint. Our sixth diagnostic rule is:

6. *Secondary patterns of sacrarthrogenetic scoliosis are produced by a sacro-iliac slip on one side, combined either with a slip or with a strain in the opposite sacro-iliac joint. Sacrolumbar complications tend to reverse the pelvic torsion.*

Disturbances in the structure and in the function of the sacrolumbar joint were present in fifty-seven (11.0 per cent.) of our cases. These records were studied separately and were classified as follows: sprain, strain, or arthritis, twenty-eight cases; unilateral apophyseal subluxation, eighteen cases; prespondylolisthesis, six cases; spondylolisthesis,* five cases (one of which was unilateral). One case of prespondylolisthesis and the case of unilateral spondylolisthesis showed the structural pattern (Fig. 2, *C-3*), but the pelvic torsion was reversed, so that the smaller iliac inclination appeared on the same side as the lumbar curve. Ten cases of unilateral apophyseal subluxation showed the functional pattern (Fig. 2, *D-4*), but with the pelvic torsion reversed, as if the lower extremities were unequal in length. Two cases of symptomless spondylolisthesis were complicated by recent sacro-iliac slips. The presence of the spondylolisthesis did not affect the interpretation of the sacrarthrogenetic scoliosis, and the reduction of the sacro-iliac slips relieved all symptoms. After reduction, these two cases did not differ from the remaining forty-three cases that showed the single transitional pattern (Fig. 2, *A-1*). The three patterns that were seen in cases of uncomplicated sacrolumbar disturbance are identical with those that regularly are noted in the literature relating to disturbances in the balance of the presacral vertebrae. Therefore, despite the small number of cases in this series, we feel justified in stating a seventh diagnostic rule:

7. *Uncomplicated disturbances in the structure and in the function*

* These cases were eliminated in the earlier studies.

of the sacrolumbar joint produce only the three primary patterns of scoliosis (structural, functional, and single transitional) that are characteristic of vertebral dysfunction in general.

The differential diagnosis between sacrolumbar and sacro-iliac conditions, in cases that show a structural pattern, depends upon the determination of the pelvic torsion, for it appears that this pattern cannot be of sacro-iliac origin, if the normal homolateral relation of torsion to curve is present. In cases that show a functional pattern, the differential diagnosis apparently can be made without additional data, since roentgenographically demonstrable sacrolumbar subluxations were present in 91.0 per cent. of the functional patterns in which a heterolateral relation of torsion to curve was present. In the single transitional pattern, the problem is more difficult, for the chances are only 2.6 to 1 in favor of a sacro-iliac dysfunction, and there usually is very little pelvic torsion or ligamentous tenderness to guide the examiner.

The average number of tender points is higher in the structural pattern (3.6 per case) and lower in the first transitional pattern (0.9 per case) than in any of the other fourteen patterns.* When other aids to diagnosis fail, the injection of small amounts of procaine (one or two cubic centimeters of a 2-per-cent. solution) into one of the tender ligaments often produces a transient aggravation of the telalgia, in part or *in toto*, which is followed by a variable period of relief from pain. The aggravation of the telalgia apparently is due to an increase in the ligamentous tension produced by the injected fluid and seems to be directly proportional to the speed of injection. Rapid injections also may cause spasm to appear in individual groups of muscles. As the anaesthetic effect of the procaine becomes evident in the relief of the telalgia, the spasm of certain muscles may be seen to relax. Even when no gross change in the visible spasm is noted, there may be marked changes in the amount of the latent spasm, as demonstrated by an altered excursion in one or more of the manipulative tests. If one has an accurate mental picture of the exact anatomical structure in which he is depositing the procaine, and if he avoids injections in the vicinity of large nerves, the positive or negative evidence produced by this simple test is of great value.**

It may be trite, but it cannot be repeated too often, that a complete correlation of the history with the patient's localization of the source of his pain, the distribution of the telalgia, the anatomical type and the posture, the general physical examination, the distribution of the ligamentous tenderness, the various manipulative tests for latent muscular spasm or contracture, the measurement of the extremities, the neurologi-

* In the first article of this series we stated that the average number of tender points in all cases was 2.7 per case.

** From the work already done with this test it seems likely that its continued use will shed new light on the exact mechanism of scoliosis. We are collecting additional data in the hope that from them we may discover the laws that govern the complete sequence,—position or motion of a joint, increase or decrease in the tension of individual ligaments, distribution of telalgia, stimulation of muscles, reflex action of muscles, segmental or inclinatory motion [3], scoliosis.

cal examination, the roentgenographic examination, and the laboratory examination is absolutely necessary in every case. We say this, because we have found the special examination described in this article to be so reliable that it tempts one to take short-cuts to diagnosis. There were twelve cases (2.0 per cent.) in this series in which the final diagnosis was made only by the therapeutic test. In two cases that showed the single transitional pattern, we went so far as to stabilize the sacro-iliac joints and, later, the sacrolumbar joint, before the final diagnosis was recorded. Despite the fact that new and accurate methods of diagnosis continually are being added to the surgeon's armamentarium, the problem of the "low-back case" never is an easy one, and there is no substitute for a thorough examination.

SUMMARY

The author has divided sacrarthrogenetic scoliosis into sixteen types and has presented a simple method by which the characteristic patterns may be recognized and recorded. Seven diagnostic rules, the accuracy of which exceeds 90.0 per cent. in the series studied, have been formulated for the interpretation of these patterns. The sixteen types of sacrarthrogenetic scoliosis have been illustrated in the form of a table, so that the etiological significance of each pattern may be determined at a glance.

CONCLUSIONS

Sacrarthrogenetic telalgia regularly is accompanied by scoliosis. In the complete examination of any case in which sacrarthrogenetic telalgia is the presenting symptom, the associated scoliosis usually is the most valuable single sign. The pattern of the scoliosis clearly differentiates sacro-iliac slips from sacro-iliac strains, sprains, or arthritis and, in three cases out of four, affords a positive differential diagnosis between sacro-iliac and sacrolumbar disturbances.

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ANALYSIS OF RESULTS OF EARLY TREATMENT OF CONGENITAL DISLOCATION OF THE HIP BY MANIPULATION AND OSTEOCLASIS FOR ANTERIOR DISTORTION *

BY ARTHUR KRIDA, M.D., PAUL C. COLONNA, M.D., AND FRANCIS J. CARR, JR., M.D., NEW YORK, N. Y.

Congenital dislocation of the hip is a major crippling affection which until fifty years ago was considered to be neither curable nor subject to reasonable amelioration.[2]

In any treatment of congenital dislocation of the hip the objective should be defined. If the objective be palliation—that is, making a good job of a poor business—it should be so specified. If, on the other hand, the objective be a substantial cure with a hip joint which is approximately or completely functionally and anatomically satisfactory, a discussion of results of treatment should confine itself to that objective.

In this study we are concerned with the curability of congenital dislocation of the hip in the above-mentioned sense.

The investigation is based upon a system of treatment devised by the senior author[3, 4] in 1924, while he was an assistant surgeon on the Service of Dr. Royal Whitman at the Hospital for the Ruptured and Crippled. The investigation embraces the patients up to three years of age who were brought to the Hospital for the Ruptured and Crippled on that Service from 1925 to 1931. It also includes the subsequent experience of the associate authors in the independent treatment and follow-up of cases up to 1935, and cases occurring on the senior author's Service at Bellevue Hospital.

A joint dislocation is curable in direct proportion to the time which elapses between its recognition and its treatment. In traumatic dislocation the time element is of the greatest importance, since neglected dislocations are notoriously difficult to reduce by reason of scar-tissue formation.

In the congenitally dislocated hip, the sequence of events is considerably "slowed up". The event of dislocation is by no means dramatic, as in a traumatic dislocation, nor are its implications so apparent. Nevertheless, from a surgical standpoint, essentially similar limiting factors which determine an end result are inherent in both types of dislocation.

The factors which hinder delayed reduction in traumatic dislocations are scar tissue and adaptive muscular contracture. In a gradual type of dislocation, such as congenital dislocation of the hip, scar tissue plays a relatively unimportant part, but muscular and ligamentous changes, and most particularly secondary changes in the architecture of bones, play a most important rôle.

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 19, 1936.

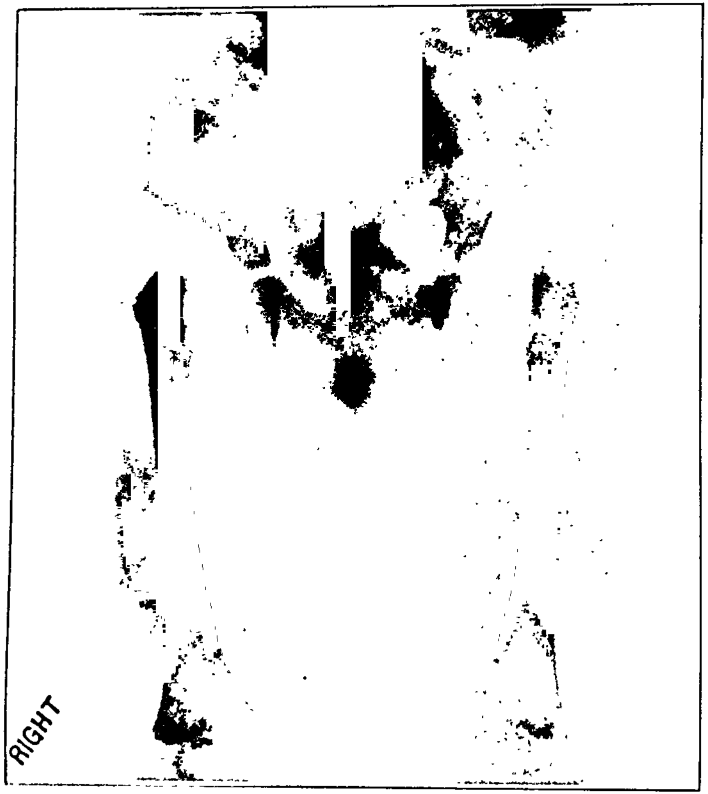

FIG. 1

R. F., aged eighteen months. Bilateral congenital dislocation of the hip. Roentgenogram, taken on November 22, 1927, and made in the usual neutral position of the limb, shows apparent shortening of the neck.

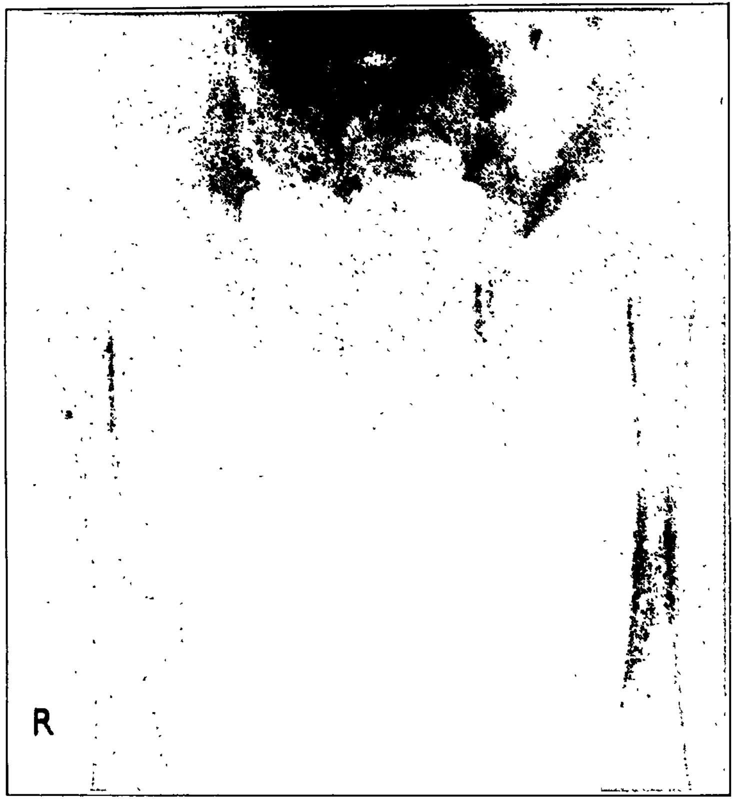

FIG. 2

R. F., November 22, 1927. This roentgenogram was made with both lower extremities in internal rotation. An adequate neck of the femur is displayed, which, in comparison with Fig. 1, indicates that anterior distortion exists.

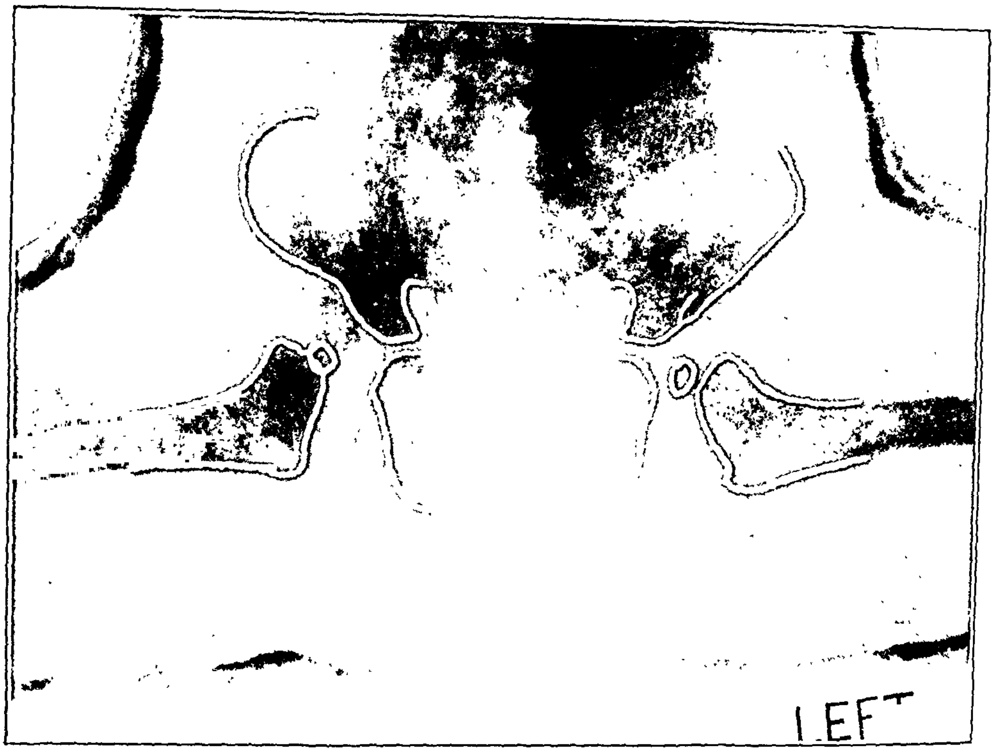

FIG. 3

R. F., December 19, 1927. Roentgenogram (outlined) showing reduction of both hips.

FIG. 4

R. F., January 17, 1928. Roentgenogram (outlined) showing the reduction converted into a "definitive" position. Both lower extremities are in marked internal rotation.

The soft-tissue alterations and adaptations have been extensively described by many writers, and will not be discussed here.

The particular architectural osseous secondary change in this connection is the rebuilding which the upper end of the femur undergoes during the period in which the dislocated hip is submitted to the test of function. It consists in an anterior twist of the upper end of that bone to a variable degree, but frequently up to an angle of 90 degrees. This developmental deformity of the femur impairs the stability of the hip, since it favors redislocation by the route taken in the original dislocation,—namely, anterolaterally. Clinically this distortion is recognizable by palpation and by roentgenograms.

The dislocated hip in the roentgenogram shows little or no neck of the femur. If the femur be rotated inwardly, an adequate neck is displayed.

The technique of treatment described by the senior author evaluates this architectural deformity, anticipates its consequences, and embodies its correction in the routine of the treatment of the dislocation.

The correction of the anterior twist of the femur is accomplished by

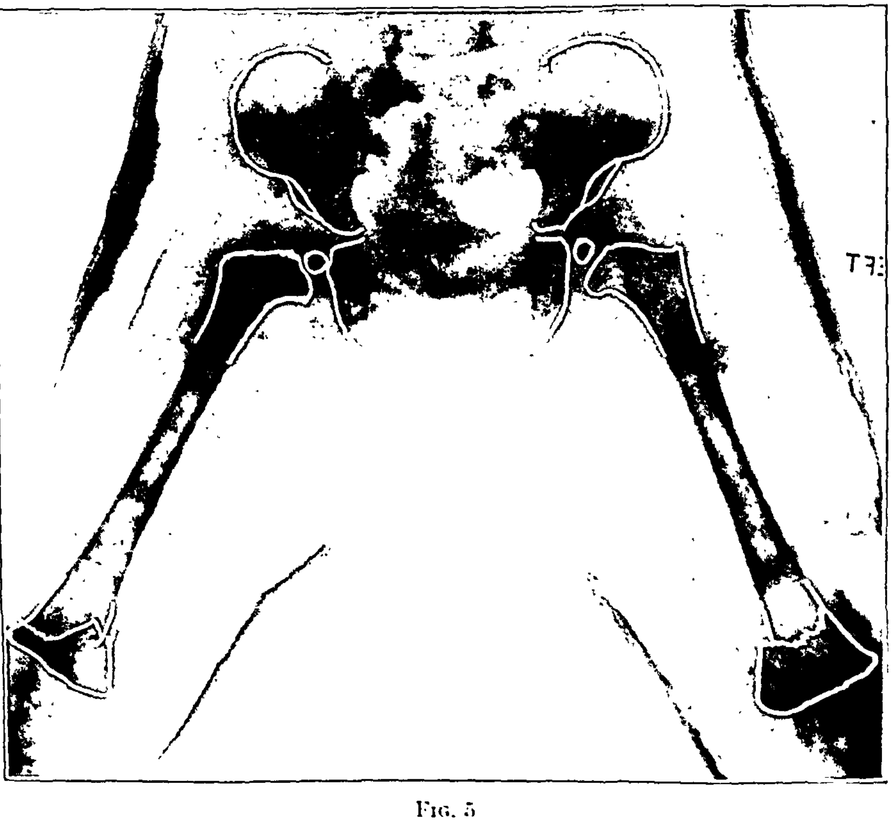

Fig. 5

R. F., April 2, 1928. The structural anterior distortion of the femora has been corrected by manual osteoclasis. The lower extremities are now in the neutral position without change in the relationship of the structures of the hip joint.

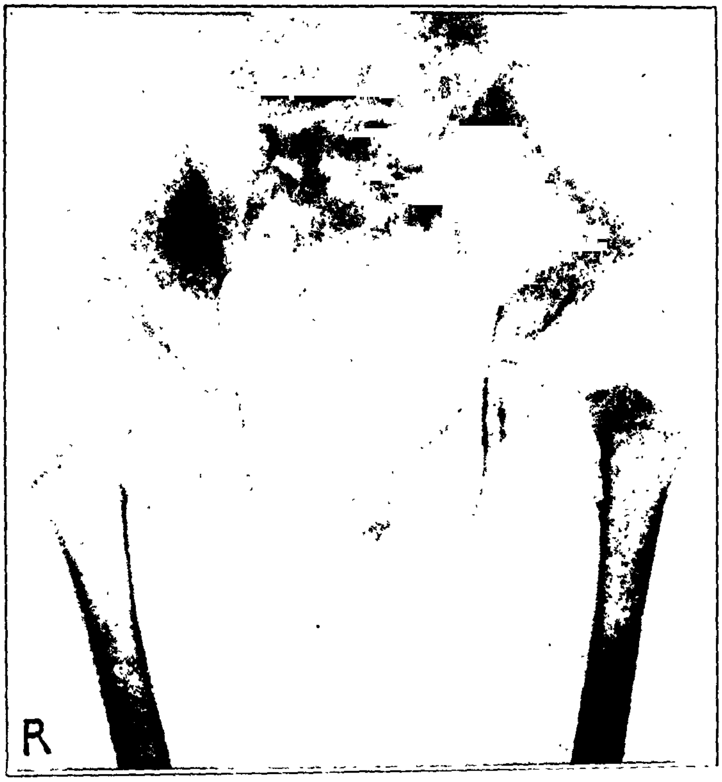

FIG. 6

R. F., June 28, 1928. The fixation treatment has been terminated and both hips are in place.

manual fracture of the femur in the mid-period of the plaster-of-Paris fixation. It is done in the lower end of the femur; it is easy to perform; and it is entirely innocuous as compared with an open osteotomy.

The dislocation in the age group upon which this study is based is nearly always easily reducible, and with less trauma to tissues than that entailed in an open reduction. Meticulous plaster-of-Paris technique assures retention. The importance of early recognition and adequate treatment has been further stressed by Colonna. Inherent instability may be demonstrable during the manipulative procedure, but redislocation does not occur while the patient is in the plaster-of-Paris dressing. The average treatment period is somewhat less than six months. In those cases in which redislocation occurred, the prognostication of the event was possible at the time of the manipulative reduction or within a few weeks after the removal of dressings.

Of the sixty-six patients comprising this series, fourteen were males and fifty-two were females. All were under three years of age. There were forty-three unilateral cases and twenty-three bilateral cases, making a total of eighty-nine hips.

In two of the bilateral cases there were associated deformities. One case presented spina bifida and club feet; the other, a spastic paraplegia. In each case the dislocation of the hip was cured.

In nineteen of the eighty-nine hips the following complications were encountered: changes allied with Calvé-Legg-Perthes disease in nine cases, or 10 per cent.; coxa vara in two cases, or 2 per cent.; and shallow acetabulum in eight cases, or 9 per cent.

Osteoclasis for correction of anterior distortion was performed on seventy-seven hips, or 86 per cent.

The minimum period of observation was one year; the maximum period, ten years; and the average period, three and two-tenths years.

Of the unilateral cases, good results were obtained in 75 per cent.,

Fig. 7

R. F., February 18, 1930.

Fig. 8

R. F., April 18, 1936, eight years after completion of treatment.

fair in 19 per cent., and poor in 6 per cent. The results secured in the bilateral cases were as follows: good in 65 per cent., fair in 17 per cent., and poor in 18 per cent.

A good result indicates a substantial cure with a hip joint which is approximately or completely functionally and anatomically satisfactory. A fair result signifies a reasonably satisfactory hip joint as far as function is concerned, with anatomical or pathological deviations of moderate degree, as demonstrated by the roentgenogram, which might ultimately impair the usefulness of the joint. A poor result denotes an imminent or accomplished redislocation. All bilateral cases in which one joint redislocated are included in this group, since from the patient's standpoint the result is a failure.

SUMMARY

Congenital dislocation of the hip is in our experience a curable affection in direct proportion to its early recognition and the institution of adequate treatment. Potential curability is considered by the authors to terminate at the age of three years.

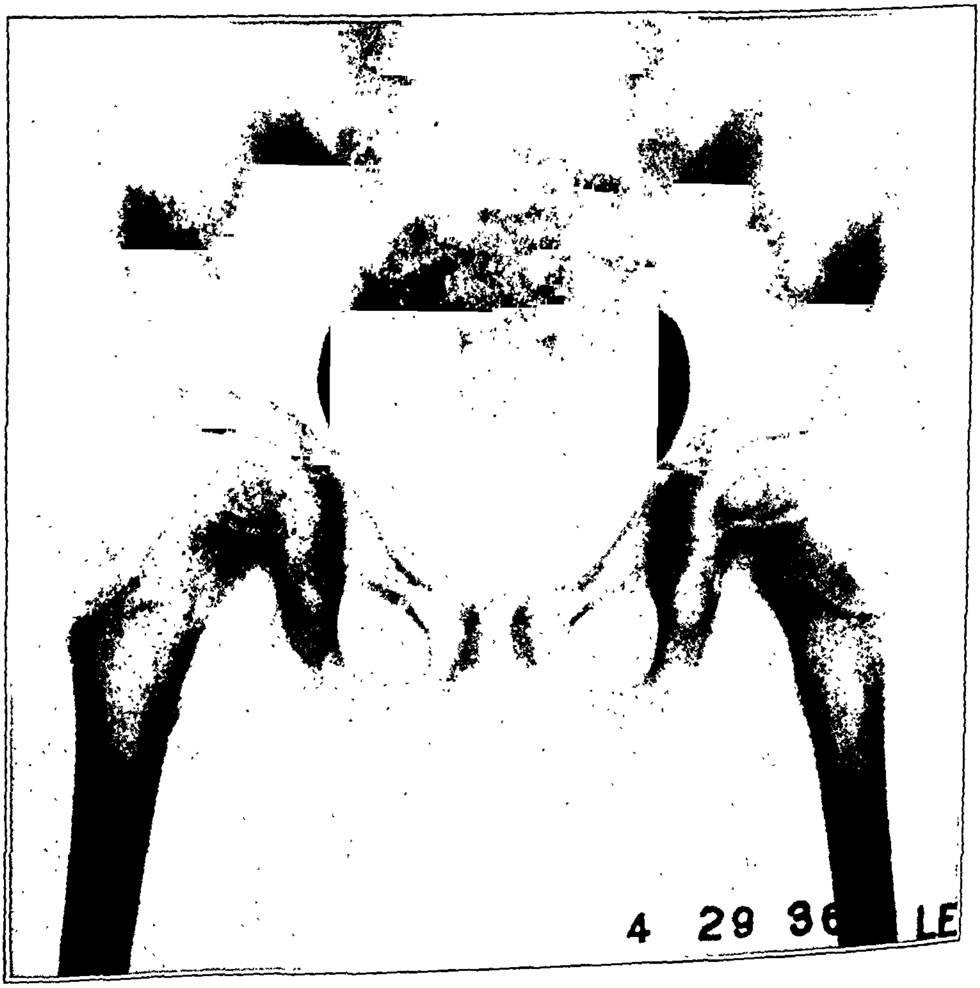

Fig. 9

N. S., aged two years. Congenital dislocation of the left hip. Roentgenogram taken on April 29, 1936, five years after cessation of treatment.

FIG. 10

A. S., aged two years. Congenital dislocation of the left hip. Roentgenogram taken on April 25, 1936, seven years after cessation of treatment.

FIG. 11

C. G., aged two years. Congenital dislocation of the left hip. Roentgenogram taken on April 27, 1936, ten years after cessation of treatment.

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REVIEW OF 100 CASES OF SCOLIOSIS TREATED BY SPINE FUSION

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During the author's fellowship at the Hospital for the Ruptured and Crippled in New York it was his privilege to review some 500 cases of scoliosis. The investigations were conducted and the conclusions were reached independently.

Of these 500 cases of scoliosis treated by spine fusion, 100 were chosen on the following basis:

1. Patients were able to return for follow-up history and examination;
2. Roentgenograms before and subsequent to operation were available;
3. Patients' own statements concerning the state of their health before and after spine fusion were accessible;
4. All patients were subjected to a test for vital capacity.

Clinically, the end results sometimes appear more favorable than they really are. This review is presented from a laboratory point of view and the writer has tried in no way to interfere with the true statistics.

Of the 100 patients, thirty-three were males and sixty-seven were females. The age incidence was thirteen years, and the duration of the deformity was five years.

The average extent of the operation was ten vertebrae. A two-stage operation was performed in nine cases. The graft broke or became ab-

TABLE I

ANALYSIS OF 100 CASES OF SCOLIOSIS WITH REFERENCE TO TYPE OF SCOLIOSIS IN RELATION TO ETIOLOGICAL FACTOR

Anatomical Types	Etiological Factors					
Curve	Idiopathy (*Cases*)	Poliomyelitis (*Cases*)	Epiphysitis (*Cases*)	Congenital Deformity (*Cases*)	Rickets (*Cases*)	Total No. of Cases
Dorsal kyphos	2		3		2	7
Right dorsal	12	6				18
Left dorsal	6	6		1		13
Right dorsal, left lumbar .	20	10	1			31
Left dorsal, right lumbar	19	8				27
Right lumbar	1					1
Left lumbar	3					3
Total	63	30	4	1	2	100

TABLE II

TREATMENT

Method of Correction	Preoperative Treatment *		Postoperative Treatment **	
	Cases	Time	Cases	Time
Convex frame and jackets . . .	66	5 weeks	79	3 months
Plaster-of-Paris jackets	16	2 years	11	5 months
Turnbuckle jackets	2	6 weeks		
Braces only	16	6 months	10	2 years
Total	100		100	

* Average preoperative corrective treatment: 3 months.
** Average postoperative corrective treatment: 6 months.

TABLE III

TYPE OF OPERATION AND RESULTS

Type of Operation	No. of Cases	Fused	Not Fused
Hibbs technique	46	24	22
Hibbs, with tibial graft	23	20	3
Hibbs, with rib graft	19	18	1
Hibbs, with beef-bone graft	12	4	8
Total	100	66	34

TABLE IV

CLINICAL END RESULTS IN 100 CASES

Clinical Aspects	Excellent	Improved	Not Improved
General health	30	53	17
Contour	13	26	61
Posture	23	27	50
Vital capacity	27	51	22

sorbed in five cases. The *mortality* rate was 1 per cent., and the cause of death was a heat stroke.

Pain was present postoperatively in seventeen cases. There was an average increase of 14 degrees in the angle of deformity in twenty-three cases.

There are a great many figures to present in this type of paper and the author has attempted to simplify and analyze them by the accompanying tables.

CONCLUSIONS

1. Scoliosis is more common in females than in males in the ratio of two to one.
2. The average age of patients when they present themselves for examination is twelve years, and the average age at the time of operation is fourteen years.
3. Idiopathic cases of scoliosis are twice as frequent as poliomyelitic cases.
4. Fusion does not always relieve pain.
5. Fusion is successful, in so far as solid bony union is concerned, in 66 per cent. of the cases.
6. The general health of the patient is improved in about 83 per cent. of the cases and the general contour in only 50 per cent. of the cases.
7. The use of an autogenous bone graft assures a more solid fusion than does the Hibbs technique alone.
8. A two-stage operation is indicated if the curve extends through more than eight vertebral bodies.
9. The frame treatment is safer, interferes less with the vital capacity, and permits the patient to be more comfortable than any other form of corrective apparatus.
10. In spite of fusion, 23 per cent. of the cases showed an average increase of 14 degrees in the angle of deformity.
11. All patients subjected to spine fusion should wear some type of support for at least eighteen months after the operation.
12. Cases of idiopathic scoliosis respond more favorably to treatment than any other type.
13. Kyphos deformities are corrected little, if any, by operation.
14. The operation should not be performed before ten years of age if solid fusion is to be expected.
15. The use of beef-bone grafts is contra-indicated.
16. In cases of scoliosis in which poliomyelitis is the etiological factor, there is a greater frequency in postoperative deformity, and a greater degree, than in any other type.
17. The mortality rate as the result of the fusion operation is practically negligible.

SUMMARY

In spite of any discouraging conclusions, it is the author's belief that the spine-fusion operation has a very definite place in the armamentarium of the orthopaedic surgeon. The procedure definitely assures more rapid correction of the deformity and offers the patient the hope of eventually discarding all apparatus with safety.

The author wishes to express his appreciation to Dr. Armitage Whitman for his help and constructive criticism. He is greatly indebted also to Mr. J. D. Flick, Superintendent of the Hospital for the Ruptured and Crippled, for permitting him the use of the x-ray laboratory to obtain follow-up roentgenograms, and to Dr. K. G. Hansson, whose department made possible the tests for vital capacity.

FRACTURE-DISLOCATION OF THE ELBOW WITH ULNAR-NERVE INVOLVEMENT

REDUCTION BY TENSION ON THE SUPERFICIAL FLEXOR GROUP OF MUSCLES *

BY ADOLPH A. SCHMIER, M.D., DETROIT, MICHIGAN

This case of fracture-dislocation of the elbow is presented because of several interesting features which it possesses,—namely, the relative infrequency with which this type of injury is met, the method of reduction employed, and the favorable result obtained, which may not however be the end result.

W. C., a boy, sixteen years of age, injured his right elbow on May 30, 1932. He fell off a chinning bar, landing on his right hand with the elbow extended. At a near-by hospital a dislocation of the elbow was supposedly reduced and immobilized in flexion. Because of persistence of pain and increased swelling at the elbow, a roentgenogram was taken the following morning. Through the courtesy of Dr. S. Millman the author had the privilege of examining and treating this patient. In addition to pain and swelling of the elbow, the patient complained of numbness in the hand. Examination revealed complete anaesthesia of the little finger, of the ulnar half of the ring finger, and of the ulnar aspect of the hand. Flexion of the terminal phalanges of these fingers was possible. Roentgenograms of the right elbow (Fig. 1), compared with those of the normal left

FIG. 1

Lateral, posterior, and downward dislocation at elbow with intra-articular interposition of epitrochlea.

* Presented at the Orthopaedic Departmental Conference of the Hospital for Joint Diseases, New York City, February 18, 1936.

elbow (Fig. 2), disclosed a fracture or separation of the epitrochlear epiphysis with its displacement into the elbow joint; also a lateral, posterior, and downward dislocation of the radius and ulna *en masse*.

Since the superficial flexor muscles of the forearm, originating from the epitrochlea by a common tendon, pronate the forearm, flex the wrist and fingers, and aid in flexing the elbow, it was felt that if tension could be applied to these muscles, the interposed epitrochlea might be dislodged from the elbow joint by the muscle pull upon it. Accordingly, under general anaesthesia the forearm was supinated, the wrist, fingers, and elbow were extended, and the forearm was slightly abducted, so as to increase the gap between the trochlea and the ulna. No more abduction was employed than is ordinarily used in the open operation. In reporting similar cases with ulnar-nerve involvement in which he operated, Cotton described a fascial or fibrous band which follows the excursion of the epitrochlea into the elbow joint, thus constricting the ulnar nerve beneath it. The author felt that if the bony fragment could be dislodged from the elbow joint and replaced to approximately its normal position by the manoeuver described, the constricting force of the fibrous band would be removed and the ulnar nerve might resume its normal function. It is important to note that hardly any force was employed. The first two attempts produced a slight "click", as though the fragment were moving between the humerus and the ulna. On the third attempt a loud report was heard. Under the fluoroscope the fragment could not be seen in the joint, and roentgenographic examination (Fig. 3) revealed the fragment displaced out of the joint and the dislocation reduced. The epitrochlea was not in close apposition with the internal condyle and it was also displaced somewhat anteriorly. Because of the marked swelling at the elbow and obliteration of the radial pulse when flexion was attempted, the arm was immobilized in considerable extension as noted in the roentgenogram. It was felt that when the swelling subsided more acute flexion at the elbow would further reduce the epitrochlea. This was

FIG. 2

Normal left elbow.

possible one week later, at which time a felt pressure pad was also applied over the internal epicondyle.

On June 30, one month after reduction, roentgenograms (Fig. 4) revealed closer approximation of the epitrochlea. However, a periosteal reaction was noted on the lateral aspect of the lower end of the humerus. This was undoubtedly due to injury of the periosteum either at the time of the accident, or during the supposed reduction, or at the time of the actual reduction. Similar periosteal reaction is described in cases treated by open reduction.

On July 25, about two months after the injury, no change was noted in the ulnar-nerve involvement. The anaesthesia previously described was still present. Action of the flexor digitorum profundus, interossei, and flexor carpi ulnaris was present but weak. The skin over the hypothenar eminence could not be wrinkled (palmaris brevis). An open operation was therefore performed. The nerve was found behind the internal epicondyle and was flattened and bound down by dense adhesions. The nerve was freed and on palpation it was found to be soft throughout, except in two spots where slight firmness was felt. It was transposed to the anterior aspect of the elbow. The epitrochlea was palpated and only a faint trace of false motion was noted, not enough to warrant either fixation or removal. The following day the patient moved the little finger much better and stated: "I know where I'm moving it." Within one week the strength of all the involved muscles was greatly enhanced. The skin over the hypothenar eminence could even be wrinkled.

On November 1, the patient complained of pain at the outer aspect of the elbow, and tenderness was present over the outer condyle of the humerus. Roentgenograms (Fig. 5) revealed an increase in the periosteal bone formation running from the external humeral condyle down toward the head of the radius. There was no union clinically to the

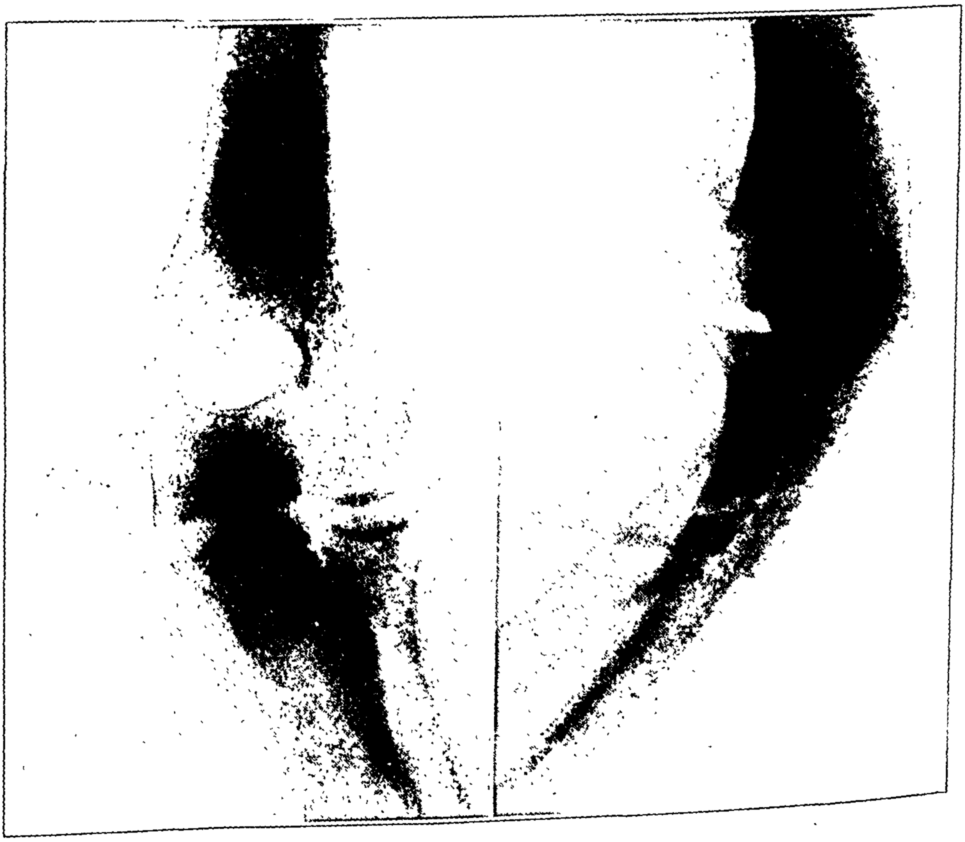

FIG. 3

Fragment displaced out of joint and dislocation reduced. Epitrochlea still somewhat lateral and anterior.

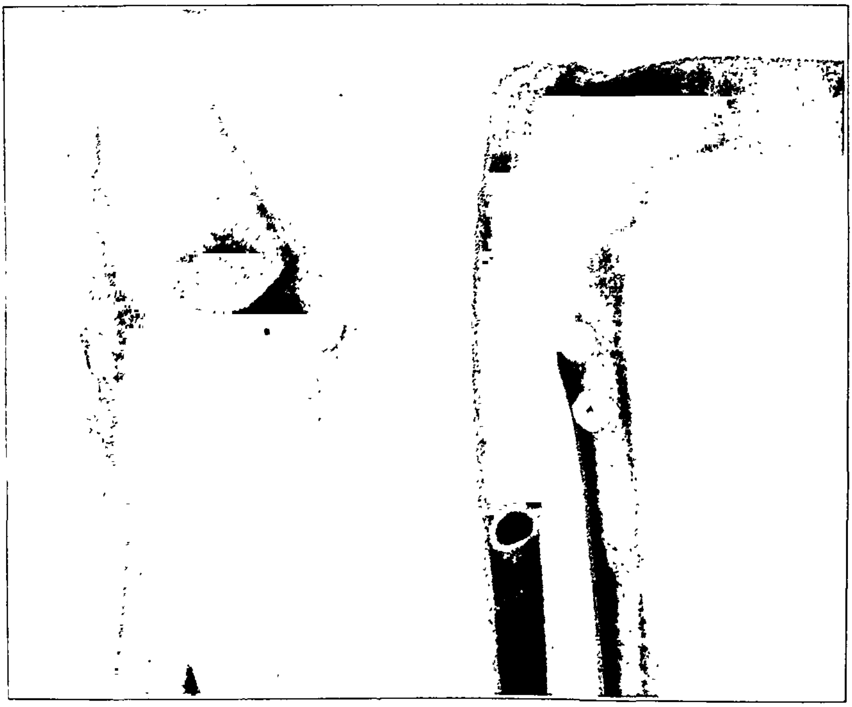

Fig. 4

One month after reduction. Closer approximation of epitrochlea. Note periosteal reaction at lateral humeral condyle.

Fig. 5

Five months after reduction. Increase in pericondylar bone formation.

radius, since pronation and supination were normal. On November 8, fifteen weeks after operation, sensation returned to the hand in the form of hyperaesthesia. On January 12, 1933, twenty-four weeks after operation, hyperaesthesia was present in the little finger and in the ulnar half of the ring finger. Sensation over the ulnar aspect of the hand was now normal. Flexion of the elbow was possible to within 5 degrees of normal, and extension to 145 degrees. Pronation and supination were normal.

On November 27, 1935, the patient was seen for follow-up examination. He had no pain in the elbow, forearm, or hand. He used his arm regularly at his work of packing ice, and the cold did not affect his hand or fingers. Flexion of the elbow was normal, and extension was possible to 165 degrees. Pronation and supination were normal. Spread and adduction of the fingers were slightly less powerful than in the normal hand, and the skin over the hypothenar eminence could be strongly wrinkled. Sensation over the ulnar aspect of the hand and over the ring and small fingers was normal. A roentgenogram (Fig. 6), taken February 5, 1936, revealed progressive bony proliferation from the outer condyle of the humerus, running toward the head of the radius. Clinically there was no union with the radius. Bony proliferation between the internal epicondyle and the humerus was also revealed.

FIG. 6

Almost four years after reduction. Progressive bony proliferation from lateral humeral condyle. No union clinically with head of radius. Beginning bone production between epitrochlea and humerus (seen better in original roentgenogram).

In reviewing the literature of fracture-dislocation of the elbow with interposition of the epitrochlea, the author has found no mention of a method of closed reduction similar to that which he has described. Cotton describes the method of Albert as follows: "Flex the arm to a right angle and separate the joint surfaces by pulling down on the upper part of the bent forearm; then swing the forearm inward." Fèvre and Roudaïtis advise abduction of the forearm in extension and supination, longitudinal traction in the axis of the arm, and flexion of the forearm with or without translatory movement to the inside. Zadek reports closed reduction by increasing the carrying angle and by then applying traction and digital pressure on the head of the radius. In all the other cases that the author has reviewed reduction was obtained either by these methods or by open operation.

In cases without ulnar-nerve involvement, the writer feels that the method of reduction which he has described is logical, since it is based upon anatomical and kinesiological data. Whenever possible, immobilization should be obtained with the forearm flexed and pronated, so as to

release any tension on the flexor muscles attached to the epitrochlea. Where ulnar-nerve involvement is present—and this is usually due to constriction by a fibrous tissue band attached to the displaced epicondyle rather than to a tear, as demonstrated by Cotton—the author believes that the closed reduction described may release the constriction on the nerve. Since the manoeuver is not a forcible one, it is probable that no further damage could be done to the nerve. If, after a reasonable length of time following reduction, there is no return of ulnar-nerve function, the nerve should be explored.

In the case described the actual significance of the bony proliferation from the external humeral condyle as regards elbow motion cannot be definitely stated. Despite the fact that repeated roentgenograms revealed a progressive ossification, it had not interfered with elbow motion in almost four years.

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END RESULTS OF FRACTURES OF THE PROXIMAL HUMERAL EPIPHYSIS

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In previous publications [1, 2, 3] the author has reported on the end results of fractures of the distal radial and tibial epiphyses. From this work the following facts have been pointed out:

1. The various epiphyses must be considered individually as to end results.

2. Each epiphysis is subject to at least three types of fracture, the end results of which vary considerably.

3. Fractures through or crushing of the cartilage plate are the prime causes of deformity. Damage of this nature is determined at the time of injury and over it we have no control.

4. Malposition is not a cause of deformity.

5. Anatomical reduction is not necessary, and osteotomy for correction is not only an unnecessary but also a dangerous procedure.

6. Premature ossification and retardation of growth are common sequelae, but in the great majority of cases they are of little clinical significance.

In this study of the proximal humeral epiphysis, the same facts hold true.

This series is composed of eleven cases which have been followed for from one to five years from the date of injury. All of these injuries occurred in male patients. Eight cases occurred between the ages of thirteen and fifteen. Two patients were eighteen and nineteen years of age. The remaining case was that of a boy six years of age. In six patients the epiphysis was displaced medially and forward, and in all but the youngest patient (Fig. 1-A) there was an associated chip fracture of the medial end of the shaft. In five cases the epiphysis was displaced laterally with a fracture of the lateral portion of the shaft. In two cases open reduction was performed and in each case the displaced head was held in place with a three-inch nail.

In all of these cases the fracture was of the first type [3],—*i. e.*, the fracture line ran through the layer of transitional cartilage and newly formed bone, which lies between the cartilage plate and the shaft proper. In no case was there a fracture through the bony epiphysis and the cartilage plate, and no evidence of crushing of the epiphysis could be seen by x-ray. The author believes crushing of the proximal humeral epiphysis to be a rare occurrence. The rarity of such compression injuries is due probably to the great mobility of the humeral head.

In six cases accurate reduction was not obtained despite repeated attempts by manipulation or by traction. (See Figures 1-B and 2-B.) In none of these cases is there any evidence of the displacement at the

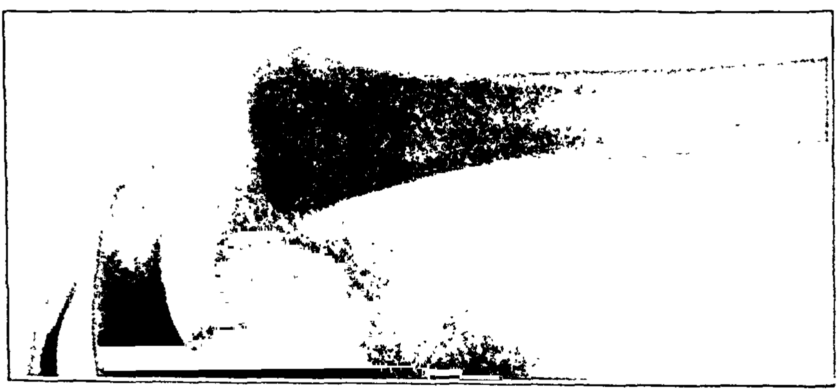

Fig. 1-A
A case of fractured proximal humeral epiphysis in a boy six years of age. Roentgenogram on admission.

Fig. 1-B
Position on discharge. Note incomplete reduction.

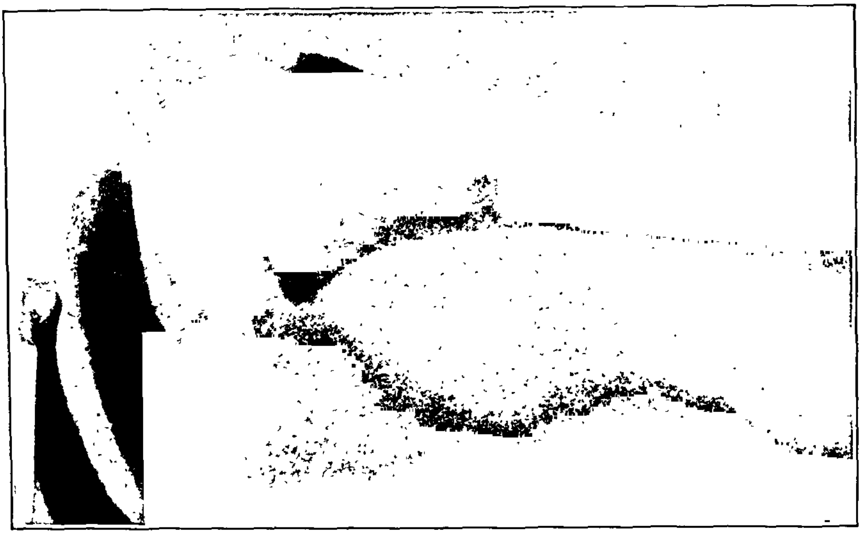

Fig. 1-C
One year later. Note complete correction of the displacement and absence of any deformity.

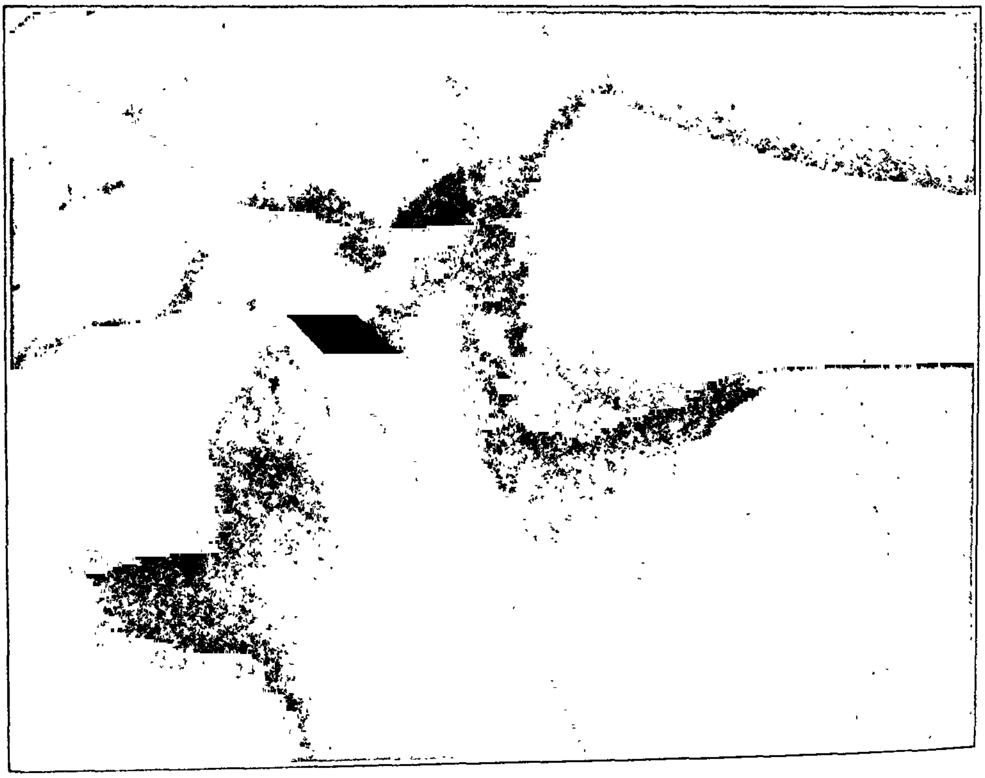

FIG. 2-A

A case of fractured proximal humeral epiphysis in a boy eighteen years of age. Roentgenogram on admission.

FIG. 2-B

Position four weeks later on discharge from the hospital. Note incomplete reduction and formation of bone by periosteum between the shaft and the displaced head.

present time. (See Figures 1-C and 2-C.) Correction of displacement occurs here as it does in the other epiphyses which have been described. When the epiphysis is displaced the periosteum on the side of the displacement remains attached to the epiphysis, but is stripped off the shaft. The periosteum then lays down bone in the triangle formed by the shaft, by the displaced head, and by the periosteum itself. The other side of the shaft becomes absorbed. In this manner the shaft is swung over to the displaced epiphysis. For the first few months there is a bowing of the shaft toward the epiphysis. This bowing is corrected within a few months as the patient uses his arm. Only rarely can this bowing be seen clinically and it is of no importance as regards function. As was found in the previous studies, malposition does not persist and is not a cause of deformity.

FIG. 2-C

Upper humerus three years later. Note correction of the displacement. Shortening amounts to a quarter of an inch.

Premature ossification occurs frequently. In the youngest patient (six years of age) ossification has not yet begun. In one of the two cases in which operations were performed, ossification is complete in both epiphyses. In the other case it is complete in the nailed epiphysis, but has not yet begun in the uninjured one. The author believes that the driving of a nail through the cartilage plate for fixation caused the prompt ossification in this case (one year from the date of injury). In the remaining eight cases ossification has begun in both epiphyses, but in each case it is more advanced on the injured side.

Shortening, due to retardation of growth, was greater in this series than was noticed in the studies of the radial and tibial epiphyses. In four cases there was no shortening; this group includes both of the cases in which operations were performed. This lack of shortening in the operated case in which fusion occurred bilaterally is due probably to the fact

that both epiphyses were about to fuse at the time of the injury. This patient was fifteen years of age at the time of injury, which occurred two and one-half years ago. In the other operated case there was no shortening; the injured epiphysis is ossified, while ossification has not yet begun in the opposite epiphysis. This boy was injured one year ago and is now sixteen years of age. If ossification occurs in the opposite epiphysis within a few months, no shortening will develop. However, further growth can occur in this epiphysis for another two years. It must be borne in mind that both of these patients are in the upper age group and both have probably reached their maximum growth. The author feels certain, however, that open reduction and fixation in younger individuals is a dangerous procedure, due to the possibility of arrest of growth caused by damage to the cartilage at the time of operation.

Shortening of from one-quarter of an inch to one-half an inch occurred in three cases, of three-fourths of an inch to one inch in three cases, and of one and one-quarter inches in one case. In this latter case the original displacement was very slight, and no attempt at correction was made. In none of these cases was the patient aware of the fact that one arm was shorter than the other. Shortening, then, is of little clinical significance in the proximal humeral epiphysis even if the loss in growth amounts to a full inch. However, if the arm were made up of two bones (as in the forearm or leg) or if it were a case of a weight-bearing epiphysis (as is the lower femoral epiphysis) then this shortening would be of definite clinical significance. The fact that shortening is more marked in the proximal humeral epiphysis than in the lower radial or tibial epiphysis is probably due to the fact that the former is more actively growing, and also to the fact that it is larger and more irregularly shaped. A greater force is thus required to displace it, with the consequent greater possibility of damage to the cartilage plate.

From this study it seems that the average age of ossification is between the sixteenth and eighteenth years. It is also to be noted that ossification normally occurs first on the medial side of the epiphysis. That portion of the cartilage plate subjacent to the greater tuberosity normally fuses last, just as that portion of the distal radial epiphysis proximal to the styloid is the last to ossify.

SUMMARY

All of the eleven cases of fracture of the proximal humeral epiphysis presented in this series were torsion fractures occurring between the cartilage plate and the shaft proper (Type-1 fracture[3]). No compression fractures of the epiphysis were seen. This type of epiphyseal injury, which is common in the ankle, the writer believes to be rare in this epiphysis, due to the mobility of the humeral head. In no case is there deformity, although accurate reduction was not obtained in six of the cases. Malposition is, therefore, not a cause of deformity. Premature ossification does occur, as does retardation of growth. Shortening was not only

much more common in this epiphysis than in the distal radial and tibial epiphyses, but was also more marked. The fact that this shortening could not be detected clinically in any case is due to the fact that the arm is non-weight-bearing and consists of but one bone. In general, the end results obtained in all of the cases in this series were good.

CONCLUSIONS

The author wishes to emphasize the fact that malposition is not a cause of deformity. Any malalignment is corrected within a few months. Deformity and shortening are due to damage to the actively growing cartilage plate. This damage is done when the accident takes place, and, when this damage is received, it is not possible with our present knowledge to prevent the inevitable growth disturbances. One can, however, add to the damage already done by attempting to get anatomical position by operative procedures.

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THE EFFECT OF LUMBAR SYMPATHETIC GANGLIONECTOMY ON LONGITUDINAL BONE GROWTH AS DETERMINED BY THE TELEOROENTGENOGRAPHIC METHOD

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Stimulation of longitudinal bone growth has recently been added to the list of effects that have been claimed for lumbar sympathetic ganglionectomy. In 1930 Harris first reported stimulation of longitudinal bone growth in man following lumbar sympathectomy in a case of limb-shortening resulting from anterior poliomyelitis. The theoretical justification of the procedure was based on the observation that lesions associated with increased vascularity sometimes produce an overgrowth of an involved limb. In a recent report by the same author lumbar sympathetic ganglionectomy was claimed to have accelerated longitudinal bone growth in twenty-one of forty-six cases in which the operation had been performed for shortening caused by anterior poliomyelitis. Also four cases of Hirschsprung's disease, in which left lumbar sympathetic ganglionectomy had been performed, showed overgrowth of the ipsilateral leg.

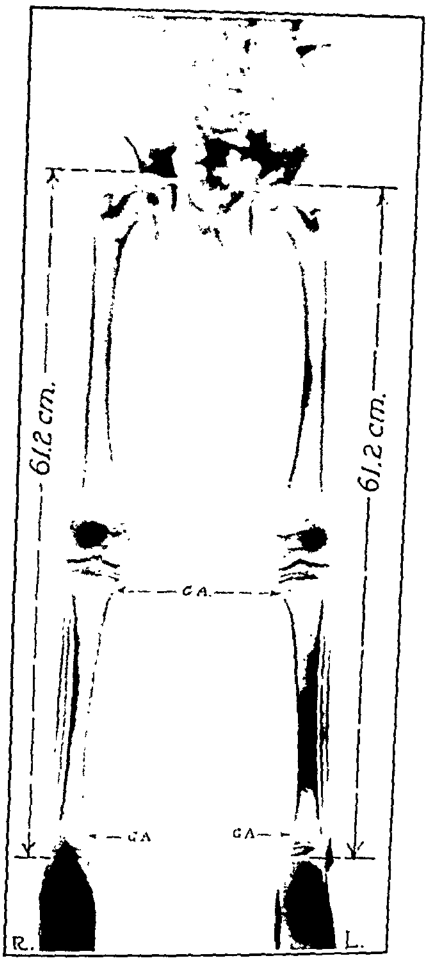

FIG. 1-A

Case 1. Teleoroentgenographic measurements of the lower extremities made nineteen months after left lumbar sympathetic [illegible]ng's [illegible] no discrepancy in limb length. *G.A.:* growth-arrest lines in the tibial metaphyses.

Experimenters have been unable to produce overgrowth of an extremity by lumbar sympathetic ganglionectomy. Cannon and his co-workers observed no increased longitudinal growth of the extremity in kittens in which the entire sympathetic chain had been removed on one side. Bacq obtained similar results in young albino rats. Bisgard also failed to find increased longitudinal growth in a half-grown monkey with symmetrical paralysis of the lower extremity due to poliomyelitis. This same author found no increase in longitudinal growth following lumbar sympathectomy in four normal young goats. Harris and McDonald performed unilateral lumbar sympathectomy upon ten kittens, twelve puppies, and eight lambs, and reported no

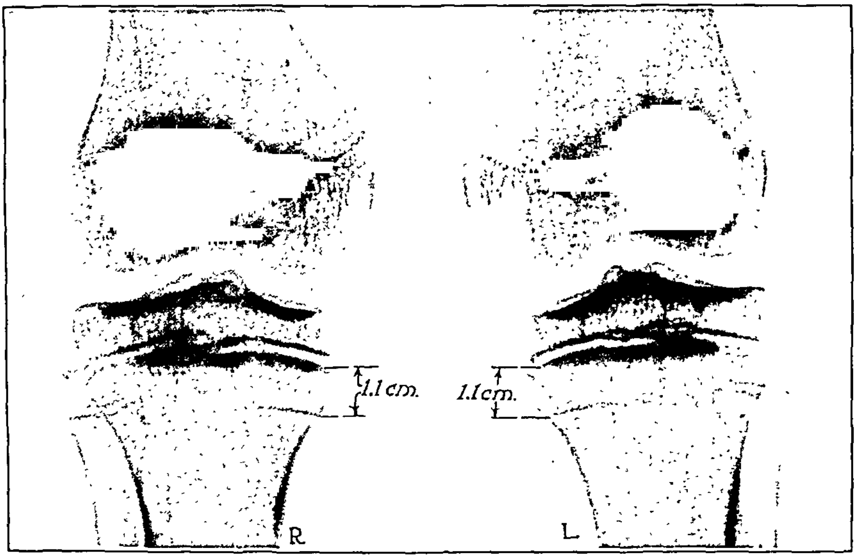

FIG. 1-B

Case 1. Roentgenograms showing growth-arrest lines present in the upper tibial metaphyses. These are equidistant from the epiphyseal line.

acceleration of longitudinal growth of the extremity on the sympathectomized side.

The evidence for increased growth following lumbar sympathetic ganglionectomy is based then upon reported limb overgrowth following the use of the operation in four cases of Hirschsprung's disease and upon reported diminution of discrepancy in limb length following the use of the operation in cases of residual paralysis due to poliomyelitis.

During the past four years three unilateral lumbar sympathetic ganglionectomies have been performed upon children in the University of Chicago Clinics. One of these was done for the purpose of remedying vascular disturbances in a case of congenital abnormality of the leg with shortening; this case, therefore, is not suitable for testing the effect of the operation on longitudinal bone growth, because contralateral epiphyseal-diaphyseal fusion had been performed for the purpose of equalizing limb length. In the other two

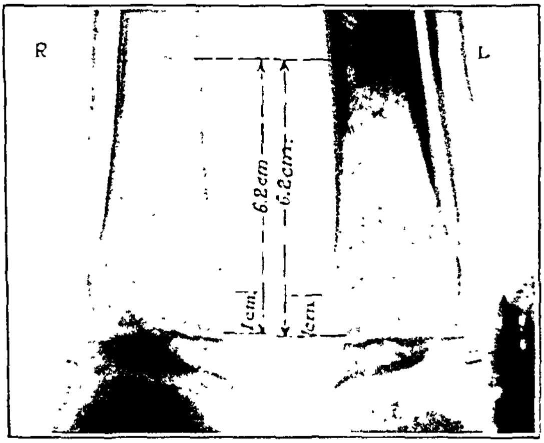

FIG. 1-C

Case 1. Roentgenograms showing growth-arrest lines in the lower ends of both tibiae. Lines are similarly equidistant from the distal tibial cartilage plate.

cases left lumbar sympathetic ganglionectomy was done for Hirschsprung's disease, and these cases are suitable for determining any possible stimulation of longitudinal bone growth.

REPORT OF CASES

CASE 1. B. N., a male, aged ten years, was seen because of constipation and enlargement of the abdomen. He had had no spontaneous bowel movement since three years of age. Enemas were usually necessary every three or four days. A diagnosis of Hirschsprung's disease was made, and, on June 26, 1934, a left lumbar sympathetic ganglionectomy was performed by Dr. C. B. Huggins. One inch of the presacral nerve, the third and fourth left lumbar ganglia, and the left lumbar sympathetic chain were removed up to a point near the left renal artery.

The result in this case was spectacular. The markedly distended abdomen, which was noted prior to operation, is no longer present. The patient is having a spontaneous bowel movement every three to four days. Teleoroentgenographic measurements of the lower extremities, made nineteen months following operation (Fig. 1-A), show no discrepancy in the length of the lower extremities. Growth-arrest lines are present in the upper and lower tibial metaphyses on both sides. Measurements showed them to be equidistant from the epiphyseal lines (Figs. 1-B and 1-C). On palpation, there is a definite increase in warmth of the left foot and leg as compared to that of the right. This difference is particularly noticeable in the distal portion of the extremity. Temperature readings, made by means of the thermocouple at various levels of the lower extremities twenty months following operation, are shown in Table I.

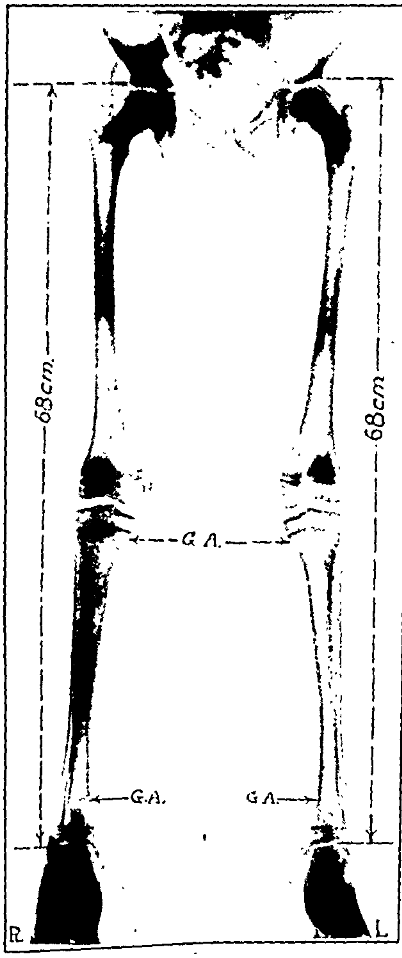

FIG. 2-A

Case 2. Teleoroentgenographic measurements of the lower extremities ten months after left lumbar sympathetic ganglionectomy. The extremities are of equal length. *G.A.:* growth-arrest lines resulting from the operation.

CASE 2. F. C., a male, aged ten years, was seen at the University of Chicago Clinics with a complaint that he had been constipated all his life. He had noticed a progressive enlargement of the abdomen for a few years prior to his admission. On examination, the abdomen was found to be distended and a tympanic note was present on percussion. A roentgenographic study showed the enlarged colon of Hirschsprung's disease. Left lumbar sympathetic ganglionectomy and presacral neurectomy were performed on March 13, 1935, by Dr. C. B. Huggins.

Following the operation the patient was promptly relieved of distention, and bowel movements became spontaneous and have thus far remained normal. Palpation of the extremities, eleven months after operation, revealed increased warmth of the sympathectomized side. This was corroborated by temperature readings made at various points on the lower extremities by means of the thermocouple (Table I). Teleoroentgenographic measurements (Fig. 2-A) of the lower extremities, made ten months subsequent to operation, revealed no discrepancy in length of the lower extremities. In this case, as in Case 1, retarded

FIG. 2-B

Case 2. Roentgenograms of knee region showing growth-arrest lines in the upper tibial metaphyses. Teleoroentgenographic measurements are shown in the margins.

growth lines, present in the upper and lower tibial metaphyses as a result of the operation, are equidistant from the epiphyseal lines (Figs. 2-B and 2-C), showing that longitudinal bone growth on the ipsilateral side had not been stimulated by the operation.

DISCUSSION

Increased warmth of the extremity occurs following lumbar sympathetic ganglionectomy as a result of vasodilatation. The influence of this increased vasodilatation, with its associated increased warmth of the limb, on longitudinal growth is doubtful because it is not comparable to overgrowth produced by pathological processes, for in these conditions, as in osteomyelitis, passive hyperaemia is present. Experimentally this is substantiated by increased osteogenesis found in passive hyperaemia by Pearse and Morton and by McMaster and Roome, whereas these same authors and Key and Moore found no increase in the rate of fracture healing in the sympathectomized extremities of dogs.

The usual clinical measurement is not accurate enough to detect small changes in limb length. Roentgenograms taken in the ordinary manner are likewise unsatisfactory. The measurements of the two patients whose cases are reported here were obtained by means of the

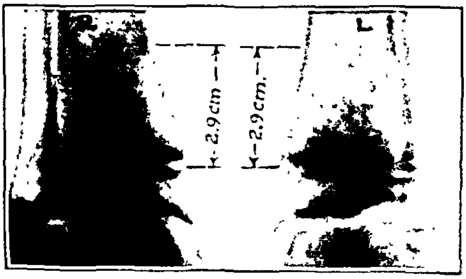

FIG. 2-C

Case 2. Teleoroentgenograms showing no discrepancy in distance of growth-arrest lines from the epiphyseal lines in the lower tibiae.

TABLE I

TEMPERATURE READINGS OF LOWER EXTREMITIES FOLLOWING LEFT LUMBAR SYMPATHETIC GANGLIONECTOMY

	Case 1 *		Case 2 **	
	Right (*Degrees C.*)	Left (*Degrees C.*)	Right (*Degrees C.*)	Left (*Degrees C.*)
Dorsum of first toe....	24.0	27.6	25.6	28.1
Dorsum of foot......	26.2	29.6	28.0	30.7
Plantar surface of foot	26.8	28.6	26.4	28.6
Anterior border of middle of tibia......	29.6	30.6	27.4	27.7
Middle thigh	30.5	30.5	27.4	27.5

* Twenty months after operation. ** Ten months after operation.

stereoscopic teleoroentgenographic method. Errors due to position of the limb and to distortion are eliminated by this technique. Although in each case there was definite clinical improvement of the Hirschsprung's disease following sympathectomy, as well as increased warmth of the sympathectomized side, no acceleration of longitudinal bone growth occurred on the sympathectomized side.

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STUDY OF THE END RESULTS IN 113 CASES OF SEPTIC HIPS *

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This study of the end results in 113 cases of septic hip lesions treated at the University Clinic was undertaken primarily to determine if possible the answer to the several questions constantly confronting us in treating this group of cases:

1. Does streptococcal infection of the hip joint react differently from staphylococcal infection?
   a. Should arthrotomy be performed in all cases showing clinical evidence of septic hip-joint involvement?
   b. Is the type of organism which produces a septic hip the determining factor in the hip reaction, or is the reaction due to the location of the lesion (1) primarily in synovia or (2) primarily in bone with secondary hip involvement?
   c. Does the age of the patient alter the course of the hip lesion?
2. What are the causes and the results of the several complications so frequently associated with septic hips,—dislocation of the hip, sequestration of the femoral head, epiphysiolysis, disappearance of the head of the femur?
3. What are the end results of treatment by various methods, at various stages of the disease, and when the disease is associated with the various types of complications?

To interpret properly the results of this study, it is essential to recognize that the majority of the reported cases fall into the subacute or chronic phases of the lesion, with relatively few cases of acute septic hips. This report makes a corollary for the excellent study by Slowick [1] of sixty cases, chiefly of acute or of early subacute pyarthrosis of the hip. With very few exceptions, at least four weeks' duration of symptoms in our cases was the minimum on admission, with the average duration running into months.

One hundred and thirteen cases of septic hip-joint lesions have been studied; in eleven the condition was bilateral. There was a slight predominance of males,—sixty-two to fifty-one females. The age incidence ranged from four weeks for the youngest to fifty-three years for the oldest; eighty-five patients were between six and eighteen years of age, and the most common age was fourteen years.

Fourteen of the 113 patients died,—twelve fr[illegible] septicaemia, one

* Read at the Annual Meeting of the American Orthopaedic [illegible]ciation, Milwaukee, Wisconsin, May 20, 1936.

ANALYSIS OF LESIONS IN PATIENTS UNDER SIX YEARS OF AGE (CLASSES 1 AND 2)

Clinical Group	Age Period (*Years*)	No. of Cases	Streptococcus	Staphylococcus	Osteomyelitis: Ilium	Osteomyelitis: Head and Neck	Epiphysiolysis Head Sequestrated	Dislocation	Other Changes	End Results
A	0–2	1		1				1		Good reduction and free motion. Small oblique acetabulum; nucleus of head not present.
	3–5	0								
B	0–2	3	Hemolyticus (2) Non-hemolyticus (1)					Spontaneous (1) Intentional (1)	Capsular distention (2)	Dislocation reduced (2); coxa vara (1); disappearance of nucleus of head (3).
	3–5	6		2	2			Accidental (1)		Dislocation reduced with disappearance of nucleus of head (1); normal hip (1).
			Hemolyticus (4)				1	Spontaneous (1)	Capsular distention (2)	Dislocation reduced with disappearance of nucleus of head (1); died (1); normal hip (1); normal hip motion, head removed, gluteal gait (1).
C	0–2	2*	Organism unknown						Disappearance of head and misshaped neck	Rapid healing; good motion. Coxa vara and gluteal gait.
	3–5	2**		2 (?)		1†		Pathological (2)	Bony ankylosis to ilium (1)	Flail hip after resection of head and neck (1). Bony ankylosis to ilium, good position (1).

* Seen at eight and seventeen years.
** Seen at nine and fifteen years after onset.
† Resection was done because of active bone infection.

from a flare-up of infection following a reconstruction operation, and one from postoperative shock.

For the purpose of this study, the cases were divided into three main groups:

Group A—Twelve Cases

The patients in this group entered the Clinic in the acute, subacute, or early chronic stages, without previous treatment, and were treated *conservatively* except for drainage of presenting soft-tissue abscesses.

Group B—Forty-Two Cases

These patients were in the acute, subacute, or early chronic phases, had not had previous treatment, and were treated *surgically* in our Clinic.

Group C—Fifty-Nine Cases

The majority of the patients in this group were in the chronic phase; a few, who had been treated outside our Clinic, were in the subacute phase. The treatment of these patients in our Clinic was mainly surgical; occasionally conservative measures were employed.

These groups are further subdivided into age periods to differentiate any characteristic reactions in the hip joint at various ages if they so occur.

Class 1: From birth to two years inclusive—six cases.

Class 2: From three to five years—eight cases.

Class 3: From six to eighteen years—the period of rapid growth to fusion of the capitate epiphysis—eighty-five cases.

Class 4: Nineteen years and over—adult changes—fourteen cases.

STUDY OF THE AGE PERIODS

Table I illustrates the type of lesion produced by the streptococcus and staphylococcus in patients under six years of age.

In each of the six cases in Class 1 (infant group) there was a good range of motion, but a gluteal gait will undoubtedly be present if the results in the older cases in Group C are any criterion. Disappearance or failure of development of the bony nucleus of the capitate epiphysis with later return or partial reappearance and maldevelopment of the head and neck of the femur is the usual result in the Class-1 age group. In all four of the cases treated at the University Clinic there was disappearance of the bony nucleus, and in the last two cases there had been no obvious return of the head at eight and seventeen years of age, respectively. A good range of motion in flexion and extension, with limitation in abduction, usually results. In all cases healing occurred rapidly without sinuses.

Although a definite similarity is noted in Class 1 and Class 2, there is a suggestion of greater frequency of staphylococcal infection in the Class-2 age period. The cases in Group C with the extensive osteomyelitis were probably of staphylococcal origin. More bone destruction is seen at this period than in the infant group.

Eighty-five of this series of 113 cases fall into Class 3, the age period

TABLE II

Streptococcal Pyarthrosis without Bone Lesions

No. of Cases	Age	Type of Organism	Soft-Tissue Changes			
			Capsular Distention	Dislocation	Loss of Joint Space	None
1	14 months	Streptococcus hemolyticus	1			
1	17 months	Streptococcus hemolyticus		1		
1	23 months	Streptococcus non-hemolyticus	1			
2	4 years	Streptococcus hemolyticus	1			1
1	8 years	Streptococcus hemolyticus				1
2	9 years	Streptococcus hemolyticus (1) Streptococcus hemolyticus and staphylococcus aureus (1)	1			1
1	13 years	Streptococcus hemolyticus			1	
1	14 years	Streptococcus hemolyticus			1	
1	16 years	Streptococcus hemolyticus			1	
1	17 years	Streptococcus hemolyticus				1
1	19 years	Streptococcus hemolyticus		1		
13			4	2	3	4

between six and eighteen years. With the exception of one case in Class 2 and of one case in Class 4, all cases of sequestration of the head fall in this group. Twenty-four of the cases of dislocation of the hip occurred at this age, and all but one of the cases of epiphysiolysis developed in this period.

In fourteen cases the onset of symptoms developed after nineteen years of age (Class 4). In one case there was a dislocation of the hip, associated with a massive sequestration of the head and neck, and dislocation was present in two other cases in this group. Septic arthritis or ankylosis was the usual result in this group.

Age, therefore, would seem to play an important part in the frequency of occurrence of septic hips and in the severity of the reaction. The infant type (Class 1), if it survives the severity of the infection, tends to recover rapidly without sinuses or recurrence of the infection,

TABLE III

STREPTOCOCCAL PYARTHROSIS WITH BONE LESIONS

No. of Cases	Age	Type of Organism	Bone Lesions
1	3 years	Streptococcus hemolyticus	Sequestrated head; epiphysiolysis.
1	6 years	Streptococcus viridans	Osteomyelitis of neck; sequestrated head.
1	10 years	Streptococcus hemolyticus	Osteomyelitis of neck.
1	11 years	Streptococcus hemolyticus	Sequestrated head.
2	12 years	Streptococcus hemolyticus (1)	Osteomyelitis of neck (1).
		Streptococcus hemolyticus and streptococcus viridans (1)	Osteomyelitis of ilium (1).
2	17 years	Streptococcus hemolyticus	Osteomyelitis of neck, sequestrated head, dislocation (1). Osteomyelitis of ilium, dislocation (1).
8			

but with a loss or maldevelopment of the head, which eventually results in a moveable hip with a gluteal gait and a coxa-vara deformity. Class 2, patients from three to five years of age, shows a greater tendency to bone infection of staphylococcal origin with an increased tendency to recurrent infection and difficulty. Dislocation of the hip is surprisingly frequent in Classes 1 and 2, occurring in seven, or 50 per cent., of the fourteen cases. Disappearance of the head, temporary or permanent, is

TABLE IV

STAPHYLOCOCCAL PYARTHROSIS WITHOUT ROENTGENOGRAPHIC EVIDENCE OF BONE LESIONS

No. of Cases	Age	Type of Organism	Roentgenographic Appearance	
			Negative	Dislocation
1	4 weeks	Staphylococcus aureus		1
1	7 years	Staphylococcus aureus	1	
2	9 years	Staphylococcus aureus (1) Staphylococcus aureus and streptococcus hemolyticus (1)	2	
2	12 years	Staphylococcus aureus	1	1
5	14 years	Staphylococcus aureus	4	1
1	15 years	Staphylococcus aureus	1	
1	47 years	Staphylococcus aureus	1	
13			10	3

TABLE V

STAPHYLOCOCCAL PYARTHROSIS WITH ROENTGENOGRAPHIC EVIDENCE OF BONE LESIONS

No. of Cases	Age (Years)	Type of Organism	Bone Lesions					
			Osteomyelitis of Ilium	Osteomyelitis of Neck	Osteomyelitis of Ischium	Osteomyelitis of Pubis	Osteomyelitis of Tuberosity	Cases with Mul[tiple] Lesions
1	3	Staphylococcus aureus	1					
2	5	Staphylococcus aureus	1					Osteomyelitis of the [ilium] and neck with d[isloca]tion (1).
2	7	Staphylococcus aureus			1			Osteomyelitis of the [...] with dislocation (1[).]
1	8	Staphylococcus aureus		1				
2	9	Staphylococcus aureus		1				Sequestrated head an[d] epiphysiolysis (1).
7	10	Staphylococcus aureus		2		1	1	Osteomyelitis of the il[ium] with dislocation (1). Osteomyelitis of the il[ium] with perforation of acetabulum (1). Sequestrated head wit[h] dislocation (1).
1	11	Staphylococcus aureus			1			
3	12	Staphylococcus aureus	1	1				Osteomyelitis of the n[eck,] epiphysiolysis, and sequestrated head (1[).]
3	13	Staphylococcus aureus	1	1				Osteomyelitis of the n[eck] and shaft; epiphysiol[y]sis (1).
7	14	Staphylococcus aureus	2	1				Osteomyelitis of the ili[um] and ischium (1). Osteomyelitis of the iliu[m] with dislocation (1). Osteomyelitis of the ne[ck] with epiphysiolysis (1[).] Osteomyelitis of the nec[k;] sequestrated head wi[th] dislocation (1).
1	15	Staphylococcus aureus	1					
2	17	Staphylococcus aureus	1					Osteomyelitis of the iliu[m] with dislocation (1).
1	18	Staphylococcus aureus	1					
1	20	Staphylococcus aureus						Osteomyelitis of the ilium and neck (1).
1	32	Staphylococcus aureus		1				
1	40	Staphylococcus aureus	1					
36			10	8	2	1	1	14

common in these two groups. Class 3, the age period between six and eighteen years, is the period of greatest frequency, of the most extensive bone involvement, and of the most complications. Class 4, patients nineteen years of age and over, goes on to septic arthritis or bony or fibrous ankylosis.

THE DETERMINING FACTOR IN THE HIP REACTION

Numerous authors have maintained that in infants and in young children the septic hip joint which results from streptococcal infection tends to heal rapidly with retention of motion and with no recurrences. The septic hip joint which is caused by staphylococcal infection, however, is prone to slow healing, persistent draining sinuses, and marked bone changes with loss of motion or with ankylosis. Slowick has suggested that the type of organism is *not* the determining factor in these two types of reaction, but, rather, the localization of the organism, whether it be primarily a synovial infection or an intra-osseous lesion producing an osteomyelitis which secondarily invades the hip joint. He also asks the question, Does the streptococcus produce intra-osseous lesions at any age? In his group of sixty cases, he found no evidence of bone involvement in the streptococcus group. However, he stated that nine cases of staphylococcal lesions were primarily synovial in origin and resembled the streptococcus group in their reaction, and twenty-eight cases were primarily bony in origin.

Table I illustrates the types of lesions produced by the streptococcus and by the staphylococcus in patients under six years of age. These were essentially the same except that osteomyelitis of the ilium was present in two cases in Class 2, Group B, in the staphylococcus group, and in Class 2, Group C, there occurred a case of pathological dislocation and a case of osteomyelitis of the neck and head of several years' duration, which probably were due originally to a staphylococcal infection. No osteomyelitis was noted in the streptococcus cases in these earlier years of life, with the exception of a sequestration of the head which may have been and probably was on a vascular basis.

Table II illustrates thirteen cases of septic hips of proved streptococcal origin without evidence of osteomyelitis. Two cases of dislocation of the hip were seen in this group.

Table III demonstrates eight cases of proved streptococcal pyarthrosis associated with definite osteomyelitic areas. Two of these patients had osteomyelitis of the ilium; three had sequestration of the head of the femur; four had osteomyelitis of the neck of the femur; and one had epiphysiolysis.

Table IV shows thirteen cases of staphylococcal pyarthrosis without bone lesions with negative roentgenographic findings in ten and dislocation of the hip in three. These cases are quite analogous to the thirteen cases of streptococcal pyarthrosis without bone lesions but with dislocation of the hip in two cases.

TABLE VI

CLINICAL RESULTS IN GROUP A (TREATED CONSERVATIVELY)—12 CASES

Cases	Gait	Range of Motion
2	Normal	Normal
3	Good	At least 50 per cent. normal
3	Fair	Ankylosis or marked limitation in good position
1	Poor	None; poor position
2	Not stated	Not stated
11*		

* One of the twelve patients in this group died.

TABLE VII

CLINICAL RESULTS IN GROUP B (TREATED SURGICALLY)—42 CASES

Gait	Cases	Range of Motion	Cases
Normal	8	Normal	9†
Good	17	Partial	15
Fair	4	Bony ankylosis**	11
Poor	5		
Not stated	1		
	35*		35

* Seven of the forty-two patients in this group died.
** All patients with ankylosis were free from gluteal gait.
† One gluteal gait classified as good gait.

Table V presents thirty-six cases of staphylococcal pyarthrosis with roentgenographic evidence of lesions which, in all probability, were primarily bone lesions and secondarily joint lesions. Sixteen of these patients had osteomyelitis of the ilium; fourteen had osteomyelitis of the neck of the femur; seven had dislocation of the hip; and four had epiphysiolysis.

We feel that these studies produce convincing evidence of the truth of Slowick's contention that the organism itself does not determine the type of reaction in septic hip-joint lesions, but, rather, that the *localization of the primary infection* is the *determining factor*. Cases of primary synovial infection of the hip joint, whether streptococcal or staphylococcal in origin, have the same characteristics of rapid healing with retention of motion and freedom from recurrence. Cases of primary osteomyelitis with secondary hip invasion, whether streptococcal or staphylococcal in origin, have the same delayed healing, persistence of sinuses, complications, and recurrences, as long as the osteomyelitis remains active.

TREATMENT

It is impossible in this paper to give the detailed study of the treatment employed in Groups A, B, and C. It will be remembered that the

TABLE VIII

Dislocation of the Joint in Pyarthrosis of the Hip

Clinical Group	Age Period	No. of Cases	Deaths	Dislocation				Fate of the Head								Acetabular Changes		
										Reduction (17 Cases)			Persistent Dislocation (11 Cases)					
										Motion	Ankylosis		Motion	Ankylosis				
				Pathological	Pathological with Sequestration	Surgical (Intentional)	Accidental	Surgical Removal	Absorption		Fibrous	Bony		Fibrous	Bony	Oblique	Septic Arthritis	Shelf Formation
A	0-2	1		1					Bony nucleus	Good						1		
	3-5	0																
	6-18	2		2					2	50%		1				1		
	19+	1		1					1	50% +							1	1
B	0-2	2		1		1			2	Good (2)						1		
	3-5	2		1			1		2	Good (1)	1					1		1
	6-18	5	1	2	1	1	1	1	3	50% (1)		2			1	2		
	19+	1	1	1														
C	0-2	0																
	3-5	2		2				1+ neck	1	Flail					1			
	6-18	17	3	12	5			5	5	50% (1)	2	2	Good (1) 50%+ (3) 30% (1)	1	3	9		
	19+	1	1	1														
		34	6	24	6	2	2	7	17	9	3	5	5	1	5	15	1	2

TABLE IX

SEQUESTRATION OF THE FEMORAL HEAD

Age (Years)	No. of Cases	Organism				Associated Factors				
		Staphylococcus Aureus	Streptococcus Hemolyticus	Streptococcus Viridans	Streptococcus Hemolyticus and Streptococcus Viridans	Dislocation	Epiphysiolysis	Osteomyelitis of the Neck	Osteomyelitis of the Ilium	None Associated
3	1		1				1			
4–5	0									
6	1			1				1		
7	0									
8	2					1	1	1		
9	3	1				1	2			
10	2	1				1	1	1		
11	0									
12	3	1			1	1	1	2		2
13	3	1					1	1		1
14	4	2				1	2	2		
15–16	0									
17	1		1			1		1		
18–21	0									1
22	1									
	21	6	2	1	1	6	9	9		4

twelve cases in Group A were treated *conservatively* except for late drainage of soft-tissue abscesses in five cases. The forty-two cases in Group B were treated *surgically;* an arthrotomy of the hip was performed in each case. In some cases this was associated with resection of the head and reduction of the dislocation, and in some with resection of the osteomyelitic areas. Obviously the patients in Group A were less seriously ill than those in Group B; otherwise arthrotomies would have been performed on these patients. Patients in Group C were treated by late incision and drainage, saucerization, sequestrectomy, and correction of deformities.

Table VI shows the clinical results obtained from the conservative treatment. Good functional results were secured in 45 per cent. of these cases, and fair results in 27 per cent., making a total of 72 per cent. of the cases in which the results were fair.

The clinical results obtained from the surgical treatment are presented in Table VII. Seventy-one per cent. of the patients in this group who survived had good function and 11 per cent. had fair function, making a total of 82 per cent. who had fair function. In all cases in which the head was removed surgically and in which there was more than 30 degrees of motion a gluteal gait developed.

The clinical results of the surgical treatment of pyarthrosis of the hip, demonstrated in Tables VI and VII, show freedom from drainage in all surviving patients and a satisfactory gait in the majority, even though ankylosis or limited motion in the joint is present. Although surgically the results are not good in relation to normal function, they are quite satisfactory from the patient's standpoint, for there is freedom from infection and pain and the patient has a useful weight-bearing extremity. Roentgenographic examination in such cases usually shows loss of the head of the femur, ankylosis, dislocation with ankylosis, etc.

There is not enough essential difference in the clinical results between the cases treated conservatively and those treated surgically to draw conclusions as to the need of operation in all septic hips. Although a simple arthrotomy may not be a harmful procedure, we see no definite indication for arthrotomy unless there is pus to be drained or an osteomyelitic focus to be eradicated.

FREQUENT COMPLICATIONS ASSOCIATED WITH THE SEPTIC HIP

Pathological Dislocation of the Hip Joint

Dislocation of the joint is a frequent complication in pyarthrosis of the hip. This occurred in thirty-four cases of this series,—in seven in Classes 1 and 2, in twenty-four in Class 3, and in three in Class 4. Pathological dislocation of the hip generally takes place when the hip is in a position of flexion, adduction, and internal rotation; this position is generally assumed after the capsule has been distended and ruptured. Only two hips in this group dislocated while on our Service, and these dislocations were the result of failure to prevent the patients from assuming this dangerous position. Traction with the leg in extension and slight abduction will prevent this accident in the majority of cases. Table VIII shows the clinical group and the age classes in which the dislocations occurred, the fate of the head, the number of cases with reduction and their end results, and the number with persistent dislocation and their end results.

There were six deaths among the thirty-four patients. Twenty-four cases showed pathological dislocation alone; six were associated with sequestration of the head. In two more, on incision and drainage of the joint, dislocation was found to have occurred; these dislocations were not reduced, in order to increase the chance of drainage. In two cases dislocation was accidental,—one followed excision of the greater trochanter and the other occurred when traction was inadvertently removed.

The fate of the head in this group of cases in which dislocation complicated the septic joint is demonstrated in Table VIII. The head was removed surgically in seven cases because of sequestration and was absorbed spontaneously in seventeen. Six patients in this group died, so that in only four cases did the femoral head survive the complication of dislocation; in each of these four cases the dislocation remained unreduced. It is possible that, in performing an arthrotomy on a septic

TABLE X

FATE OF THE SEQUESTRATED HEAD

Clinical Group	Age Period (Years)	No. of Cases	Dislocation	Epiphysiolysis	Osteomyelitis of the Neck	No Associated Changes	End Results: Surgical Removal	End Results: Conservative
A	0-2	0						
	3-5	0						
	6-18	1				1		Fibrous ankylosis in poor position. Arthrodesis performed later. Loss of head.
	19+	0						
B	0-2	0						
	3-5	1		1			Normal motion, gluteal gait.	
	6-18	8	1	4	4	2	Normal motion, gluteal gait (2). Fibrous ankylosis, no motion (1). Died (1). Dislocation reduced, 50% motion, gluteal gait (1). Bony ankylosis, good gait (2).	Loss of head, fibrous ankylosis, and no motion (1).
	19+	0						
C	0-2	0						
	3-5	0						
	6-18	10	5	4	5		Died (3). Fibrous ankylosis, no motion (4). Motion 50%, gluteal gait (1). Bony ankylosis (1). Bony ankylosis to the ilium (1).	
	19+	1				1	Fibrous ankylosis, no motion.	
		21	6	9	9	4	19	2

hip with dislocation, it is occasionally wise to leave the head displaced for a time in order that more satisfactory drainage may take place. The head may be replaced after the acute reaction has subsided. In seventeen cases reduction of the dislocation of the hip was obtained; in three cases fibrous ankylosis developed and in five bony ankylosis occurred. Four of this group of patients had good motion in the hip; four had 50 per cent. or more of the normal range of motion; and one had a

TABLE XI

SUMMARY OF 113 CASES OF SEPTIC HIP

Age Range:			
4 weeks to 53 years			
Clinical Groups:			
A			12 cases
B			42 cases
C			59 cases
Analysis of Cases:			
Total number of cases			113
Total number of hip joints involved			124
Number of cases of bilateral involvement			11
Number of deaths (two bilateral cases)			14
Lesions:			
Osteomyelitis of the ilium			25 cases
Osteomyelitis of the pubis			3 cases
Osteomyelitis of the ischium			3 cases
Osteomyelitis of the femoral neck			30 cases
Pathological fracture of the femoral neck			4 cases
Complications:			
Disappearance of the femoral head			43 cases
Surgical removal		19 cases	
Non-surgical		24 cases	
With dislocation	17 cases		
Sequestrated head	2 cases		
Absorption	5 cases		
Sequestration of the femoral head			21 cases
Epiphysiolysis (produced by traction in 2 cases)			9 cases
Dislocation of the femoral head			34 cases
Nearthrosis (at epiphyseal line with fusion of head to acetabulum or ilium)			8 cases
Coxa magnum			5 cases

flail hip. In eleven cases the dislocation persisted, with five cases of bony ankylosis and one case of fibrous ankylosis. There was a good range of motion in one of these cases of persistent dislocation, 50 per cent. or more of normal in three cases, and 30 per cent. in the fifth case.

Fourteen of the twenty-eight surviving hips had good or fair range of motion; five of these hips were still dislocated.

The complication of dislocation of the hip, associated with septic hip, may have been nature's way of improving drainage of the septic joint, but in general it resulted in a poorly functioning joint.

Sequestration of the Femoral Head

In studying this problem the questions to be considered are:

1. Why does the head sequestrate?
2. What happens to the sequestrated head if it is not removed?
3. What is the result if the sequestrated head is removed?

Table IX shows the age periods in which sequestration occurred and the organisms responsible in those cases where they were isolated.

TABLE XII

ANALYSIS OF CASES IN WHICH ANKYLOSIS OCCURRED

Area	Bony Ankylosis		Fibrous Ankylosis	
	Age Group	*Cases*	*Age Group*	*Cases*
Head to acetabulum	A	2	A	4
	B	10	B	8
	C	10	C	16
Head or neck to ilium		5		5
Neck to acetabulum after sequestrectomy of head		5		13
Total		32		46

In ten of these cases the organisms were known; six cases were caused by staphylococci and four by streptococci. It is interesting to note that dislocation of the hip was associated with six of these cases, epiphysiolysis with nine, and osteomyelitis of the neck with nine, leaving only four cases of sequestration of the head without definite pathology to account for the sequestration. Undoubtedly interference with the blood supply to the head itself plays a part in the sequestration. It would seem from Wolcott's[2] excellent anatomical dissections that more chance for damage to the branch of the median circumflex artery in the posterior capsular location would be produced by Ober's incision than by the anterior or anterolateral approach. Thrombosis of the ligamentum teres, or rupture of the ligamentum teres as necessarily occurs in dislocation of the hip, is undoubtedly a factor in some cases of sequestration of the femoral head.

The fate of the sequestrated head is demonstrated in Table X. It will be noted that there were twenty-one sequestrated heads in this group and nineteen were removed surgically. Several of these were not removed at the initial arthrotomy, but presented themselves spontaneously in the wound at subsequent dressings and were removed. In two cases the heads were not removed, but later were completely absorbed *in situ* with resultant fibrous ankylosis. Three of the nineteen patients had normal motion, but a marked gluteal gait concealed by the Achilles push-off action that obscures the pelvic drop, a trick motion which patients with positive Trendelenburg symptoms learn. Two patients had 50 per cent. of normal motion with a definite gluteal gait. Six patients had fibrous ankylosis with little or no motion, and four had bony ankylosis,— in three ankylosis developed in the acetabulum and in one the joint dislocated and ankylosed to the ilium. Four of the twenty-one patients died. The amount of resultant shortening of the extremity in this group has not been compiled in this study.

The complication of sequestration of the head is, therefore, a serious obstacle to normal function of the hip.

Disappearance of the Femoral Head

There were forty-three cases in which the femoral head was either removed surgically (nineteen cases) or absorbed spontaneously (twenty-four cases). The spontaneous absorption of the head occurred in seventeen patients with dislocation of the femoral head, in two patients with sequestration of the head which was not removed, and in five patients under six years of age. Absorption of the femoral head in our series resulted from pyarthrosis of the hip in patients under six years of age, from the complications of sequestration of the head, or from pathological dislocation of the hip joint.

CONCLUSION

A study of the end results (Tables XI and XII) of the treatment of the subacute and chronic septic hip joints, with which this paper deals almost entirely, shows a relatively low death rate and a high frequency of healing of the infection. From this standpoint the results are satisfactory, but of the 113 cases there were only seven in which the hip was normal. Twenty-three patients with septic arthritis had a functional joint with at least 50 per cent. of normal motion. The remaining eighty-three cases demonstrated numerous severe complications, resulting in irreparable functional damage to the hip joint proper. The poor prognosis in cases in which there are complications such as dislocation of the hip, sequestration of the head, and epiphysiolysis, is readily confirmed by the results in this paper. Inasmuch as neither dislocation of the hip, with the exception of two cases, nor epiphysiolysis developed while under our care, we feel that they are preventable complications in the most part if an arthrotomy is performed early in the course of the disease and if the hip is fixed in mild abduction and extension by traction or plaster.

The results here recorded point to a more favorable prognosis in the case of a primary synovial lesion, whether due to streptococcal or staphylococcal infection. If the patient survives the acute infection, rapid healing with good motion and no recurrence is the rule. If the lesion is primarily osteomyelitic in origin, the prognosis is much poorer and early and radical surgery is necessary. The age of the patient plays a definite part in the type of lesion and is of importance from a prognostic and therapeutic standpoint. Under two years of age, there is very good expectation that the lesion is primarily synovial; under five years, without evidence of bone infection, the prognosis is good. Between six and eighteen years is the period of the greatest number of complications. It is during this period that osteomyelitis most commonly develops, and the prognosis for function is much poorer.

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ENLARGED INTERMETATARSOPHALANGEAL BURSAE OF BOTH FEET

A Case Report

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From the Hospital for Joint Diseases *

As is now coming to be recognized, the intermetatarsophalangeal bursae are four in number and are situated between the heads of the metatarsal bones: the three medial bursae are almost constant, the fourth is only occasionally present.

The presence of intermetatarsophalangeal bursae is not mentioned in American or in English text-books on anatomy, although Gruber in discussing the subject recognized these bursae as far back as 1795. Just as their presence anatomically has been ignored, so has their clinical significance been almost completely neglected.

Probably the first to recognize disturbances of this bursa clinically was Hertzler in 1926. Many of his cases had been previously treated for periods averaging from a few months to five years under the diagnosis of weak feet or metatarsalgia. Relief of symptoms promptly followed the employment of such procedures as are commonly used to control inflamed bursae.

Next to call attention to this condition clinically was Roberts, in March 1929. He reported twenty-six cases of metatarsal bursitis, of which fourteen were cured by conservative and twelve by operative methods.

Differential diagnosis depends upon:

1. Circumscribed tenderness situated between the heads of the metatarsal bones;
2. Pain in the anterior portion of the foot when this area is compressed laterally;
3. Pain caused by hyperflexion of the toes, due to pressure on the bursae through tension of the overlying tissue.

The author has recently had the opportunity of treating the following case:

The patient, an adult female of thirty-eight years, a dancer by profession, was admitted to the Hospital because of painful masses on both feet, of several years' duration. About five years previously, she had first noticed that the left leg became more tired than the right. This discomfort had continued until about three years before admission, when the patient had begun to suffer quite severe pain near the first left metatarsophalangeal joint, associated with some swelling and a mass. This condition had persisted despite treatment with metatarsal padding and physiotherapeutic measures. Eight months before admission, following an attack of acute tonsillitis, the patient had experienced what was termed "inflammatory rheumatism", involving the foot, the ankles, and the knees. At this time, she had noticed a mass about the fifth right metatarsophalangeal joint. Since this initial attack, she had experienced three others, chiefly localized at the site of the masses. Pain and swelling had persisted in these localities, so that walking had become quite difficult.

* Service of S. Kleinberg, M.D.

Examination showed an early bilateral hallux-valgus deformity with depression of the anterior metatarsal arch. On the left, a swelling was present between the heads of the first and second metatarsal bones. This consisted of a small tender mass, about two centimeters in diameter, unattached to the overlying skin. A smaller tender area was present on the right foot between the heads of the fourth and fifth metatarsal bones, and, upon upward pressure on the plantar surface, a distinct mass was likewise discernible. Roentgenographic examination was negative.

At operation, a two-inch incision was made on the dorsal surface of the left foot, extending upward from the webbing of the toes, between the first and second metatarsal bones. Directly beneath the skin a large cystic mass was found lying between and adhering to the first and second metatarsals. A short cystic projection was discovered, extending proximally between the adjacent bones. This entire mass was completely removed. A similar procedure was performed on the right side, the incision having been

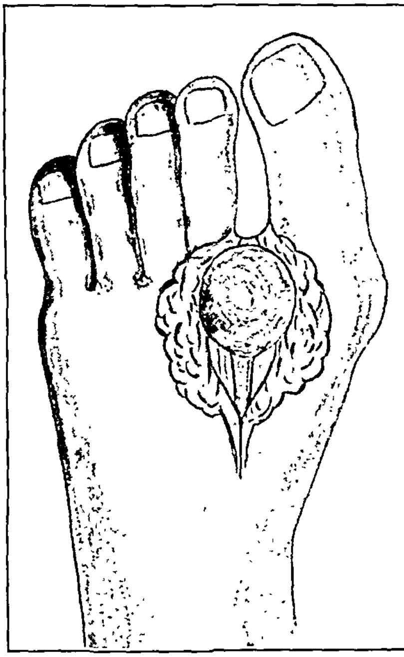

FIG. 1-A

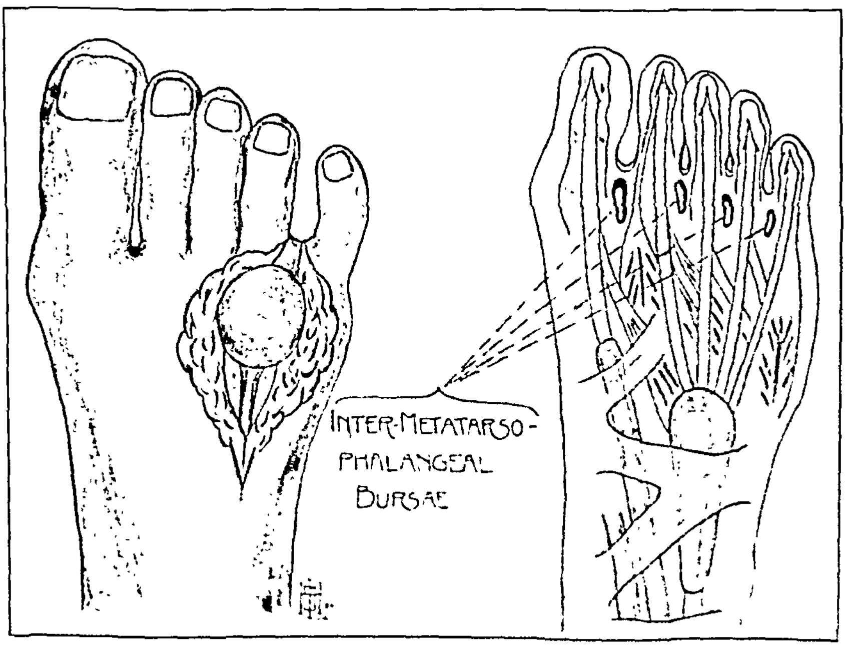

FIG. 1-B FIG. 1-C

Fig. 1-A and Fig. 1-B: Appearance of enlarged intermetatarsophalangeal bursae when exposed at operation.

Fig. 1-C: Appearance of normal intermetatarsophalangeal bursae. (*Sketched from Fig. 408, p. 368, Vol. II, "Hand Atlas of Human Anatomy" by Werner Spalteholz.*)

made over the dorsum of the foot between the fourth and fifth metatarsal bones. A cystic mass, similar to but somewhat smaller than that on the left foot, was found.

Histological study showed a dense, highly cellular layer of young, actively proliferating fibroblasts,—a membrane which was found to be invaginated and lined by flattened synovialike cells. There was a slight round-cell infiltration. The specimen from the right foot was similar to that of the left with the addition of areas of necrosis and leukoid degeneration with considerable mononuclear infiltration. The pathological diagnosis was chronic bursitis.

The postoperative course was uneventful, and the patient was discharged in two weeks, walking and free from pain.

The patient had had symptoms of over five years' duration. No evidence of any mass had appeared until three years prior to admission. The patient had been treated during this period by the usual methods employed for relieving pain in cases of metatarsalgia, with slight relief of symptoms. In this case, the condition no doubt was initiated as a result of frequent trauma induced by the patient's occupation as a dancer, with perhaps an exacerbation or aggravation of preexisting bursitis, caused by the tonsillitis eight months before admission. Because of the size of the masses, operative intervention was considered the best means of treatment.

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TORTICOLLIS

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From the Hospital for Joint Diseases *

The author may be accused of splitting hairs, but to him torticollis, due to a shortened clavicular head of the sternomastoid muscle, is a distinct clinical entity. This condition has been termed "clavicular" torticollis.

In the normal person the clavicular head blends with the sternal head below the middle of the neck, and is an individual unit only at its origin. A small hiatus is present between the two heads which cannot be seen even with the muscle tensed. Should torticollis take place in such an individual, tension on the shortened muscle will make the sternal head very conspicuous, but the clavicular portion *may* be seen as a tense cord for a very short distance, beginning at the clavicle and close to the sternal head. No hiatus is visible. The head proper is not only tilted to the same side, but the chin is pointed well away from that side. The *sternal* muscle is the predominating factor. The *contour* of the neck and shoulder is *not* affected because of the oblique course of the muscle, from behind forward.

"Clavicular" torticollis presents a different picture entirely. The clavicular portion of the muscle is very prominent. It extends in a longitudinal line from the mastoid almost to the midpoint of the clavicle and is *not* blended with the sternal portion at all (Figs. 1-A, 1-B, and 2-B). There is a distinct hiatus between the muscle bellies, extending in some cases from the origin to the insertion (Fig. 2-B). Here the sternal portion is more a part of the clavicular one. In fact, in some cases the sternal head cannot even be seen (Fig. 1-A). Because its course is longitudinal instead of oblique, it pulls the head directly to the same side, but does not rotate the chin to the

FIG. 1-A FIG. 1-B

Case 5. Before operation.

Fig. 1-A: Note division of supraclavicular fossa by clavicular head. Sternal head is not seen. Broadening of neck is quite apparent. Note scars of two previous attempts at correction.

Fig. 1-B: Clavicular head is not blended with sternal head. Note its straight course from clavicle to mastoid.

*Service of H. C. Frauenthal, M.D.

FIG. 2-A FIG. 2-B

Case 7. Before operation.

Fig. 2-A: Webbing of right side of neck. Neck broadened. Normal outline of neck is disturbed,—longitudinal line meeting a concave one. Loss of inward dip of neck as it approaches shoulder outline.

Fig. 2-B: Note pronounced hiatus between the clavicular and sternal heads, bisected supraclavicular fossa, and course of clavicular head.

FIG. 3-A FIG. 3-B

Case 7. After operation.

Fig. 3-A: Note outline of neck and shoulder, especially the inward dip of the neck near its base.

Fig. 3-B: Supraclavicular fossa reestablished. No hiatus.

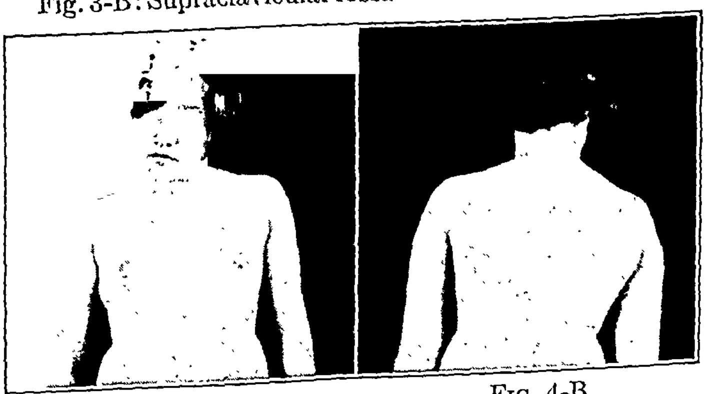

FIG. 4-A FIG. 4-B

opposite side (Figs. 4-A and 5-A). Also, because of its aberrant course, it affects the normal contour of the neck and shoulder and gives the neck a very broad appearance. On the affected side (Fig. 5-A) the neck appears webbed. The outline is a straight line dropped from the mastoid, crossing a concave curve. This straight line obliterates the normal inward dip of the neck line just before it blends with the outline of the shoulder (Figs. 2-A, 4-B, 5-B, and 7). It also divides the supraclavicular fossa into two parts (Figs. 1-A and 2-B).

Ordinary operative measures will correct the tendency to hold the head tilted to one side, but will not restore the normal curved outline of the neck. The clavicular head becomes reattached to its origin and even in its length-

FIG. 4-A and FIG. 4-B

Case 2. After operation.

Fig. 4-A: *Not* one of the series of transplantations. Head is tilted to left, but chin is *not* turned to right. Broad neck on left.

Fig. 4-B: Webbing of neck on left side; disturbed outline; loss of inward dip of base of neck.

ened state stands out prominently, away from the neck proper. Although the head deformity is overcome, the cosmetic deformity is unimproved (Figs. 4-A and 4-B).

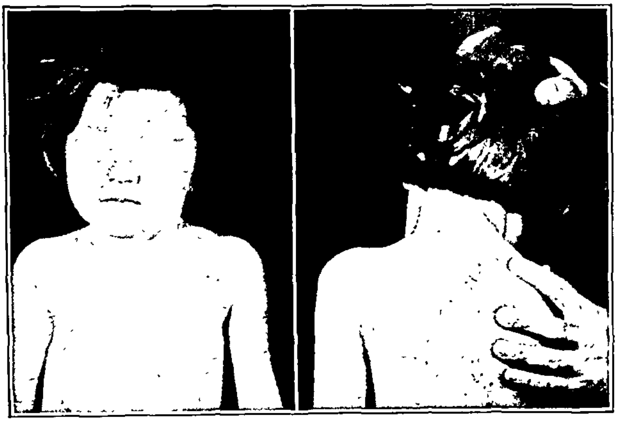

FIG. 5-A FIG. 5-B

Case S. Before operation.

Fig. 5-A: Head tilted, but not the chin; left side of neck is broader. Even the outline of the mandible is obscured.

Fig. 5-B: The muscle in this case was so thick that it hid almost the entire ear. Note the straight course of this muscle and how sharply it meets the concave outline of the neck and shoulder.

The author's series consisted of ten cases. In the first case a tenotomy of the sternal and clavicular heads was done, plus a myotomy of the platysma myoides and a section of the deep fascia. In the second case, in addition to these steps, the clavicular head was sutured to the undersurface of the sternal belly (Figs. 4-A and 4-B).

FIG. 6-A FIG. 6-B

Case S. After operation.

Fig. 6-A: Clavicular head cannot be seen.

Fig. 6-B: Compare with Fig. 5-B.

In neither case did the head deformity recur, but the cosmetic effect was anything but beautiful. These poor results were seen when the plasters were removed after five weeks. There was a complete reformation of the severed muscle (Figs. 4-A and 4-B). In both cases, a second operation was refused.

To eliminate these eventualities, the following technique was originated.

OPERATIVE TECHNIQUE

An oblique incision, about two inches long, is made between the two heads of the sternomastoid muscle. The incision begins just above the clavicle and extends toward the mastoid. The clavicular head is isolated and tenotomized close to the clavicle. It is then separated along its course up to its bifurcation with the sternal portion and in some cases right up to the mastoid. All structures in front of the deep layer of cervical

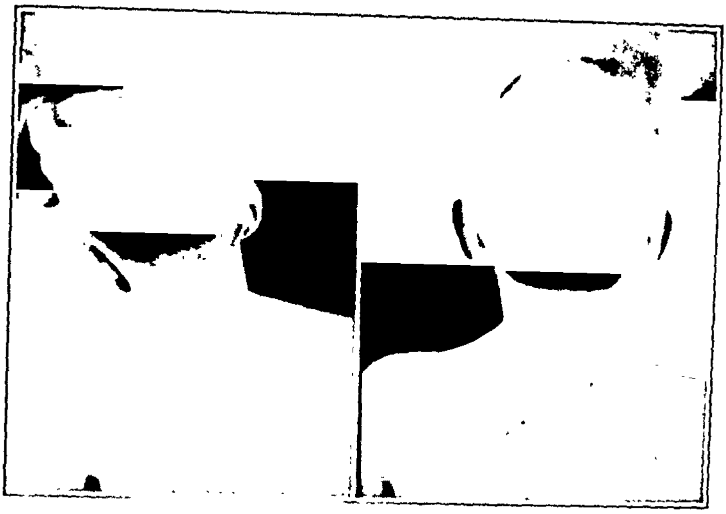

FIG. 7 FIG. 8

Fig. 7: Case 9. Before operation. Note prominence of weblike appearance of right side of neck.

Fig. 8: Case 9. After operation. Normal symmetry of both sides of neck.

fascia are cut as far back as the anterior margin of the trapezius. The fascial compartment of the sternal belly is then cut from the sternum to a point just *above* the bifurcation. The fascia surrounding this muscle is now almost completely separated from it. This is not so simple in all cases. The clavicular belly is now swung under the sternal one and fixed in that position by two sutures. The fascial compartment is then closed with a continuous stitch. If, at this time, it is found that the sternal head is somewhat contracted, it should be tenotomized close to the sternum. Of the eight cases in which this operation was performed sternal tenotomy was unnecessary in four. The skin is closed with a subcuticular stitch.

After-Care

The after-treatment consists of a Calot jacket, applied forty-eight hours after operation and worn for five weeks. This is followed by the wearing of a leather collar for an additional six to nine months. This immobilization is constant for all forms of torticollis.

End Results

In every one of the eight cases operated upon both the tilting of the head and the cosmetic deformities were completely corrected. (See Figures 3-A, 3-B, 6-A, 6-B, and 8.) Postoperative results range from six months to three years.

SUMMARY

Torticollis, due to a shortened clavicular head of the sternomastoid muscle, produces a cosmetic deformity of the neck which can be corrected by a physiological transplantation of the offending muscle. This procedure, employed in eight cases, gave uniformly excellent results. There were no recurrences.

NOTE: Since the submission of this article for publication in May 1936, three other cases have been added to this series. All three patients were operated on in June. One of them was the patient in Case 2, who had previously refused reoperation. The results in these three cases are as excellent as those reported in the article.

THE FUNCTION OF SEMILUNAR CARTILAGES *

BY DON KING, M.D., F.A.C.S., SAN FRANCISCO, CALIFORNIA

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There has been much speculation concerning the function of the intra-articular semilunar fibrocartilages. The functional rôles assigned to these cartilages are as follows:

1. Protection of the articular hyaline cartilages by absorbing shocks;
2. Increasing of joint stability by deepening the female portion of the joint (tibial condyles) for reception of the male portion (femoral condyles);
3. Relieving incongruity and increasing mobility between the meshing surfaces of the femur and the tibia by acting as peripheral, elastic, movable washers.
4. Lubrication.**

In spite of the various functions assigned to the semilunar menisci, patients seem to get along quite satisfactorily following the extirpation of these cartilages. Sutton (1897) suggested that they are functionless remains of leg-muscle origins, which formerly arose intra-articularly.

In a short series of experiments on the knees of dogs it was noted that partial or complete meniscectomy was followed by some degeneration of the articular cartilages of the medial tibial and femoral condyles [1]. This observation suggests that the menisci do protect the articular hyaline cartilages. In an effort to throw further light on this problem the following experiments were conducted.

EXPERIMENTS

Dogs 1 and 2

The knee joints were opened by curved internal incisions. The lateral ligaments were cut and sutured, and the wound was closed as atraumatically as possible. Ninety days later both knees were found to be normal.

Dog 3

A complete extirpation of the left internal semilunar cartilage was done. Two hundred and five days later the apparently normal joint was opened. The extirpated cartilage was replaced by a disc of glistening white tissue grossly like fibrocartilage (Figs. 1-A, 1-B, 1-C, and 1-D). There was a moderately severe degeneration of the articular cartilage of the internal femoral and tibial condyles.

Dog 4

Subtotal excision of the internal semilunar cartilage of the left knee was performed. Ninety-eight days later the extirpated meniscus was found to be replaced by a newl

* The experimental work was aided by a grant from the Fluid Research Fund of the Rockefeller Foundation to Stanford University School of Medicine.

** The most effective form of lubrication depends upon the formation of a film of the lubricatory fluid between the moving surface and its bearing. The wedge-shaped semilunar cartilages insure the formation of similarly shaped synovial films between the femoral and the tibial condyles (MacConaill).

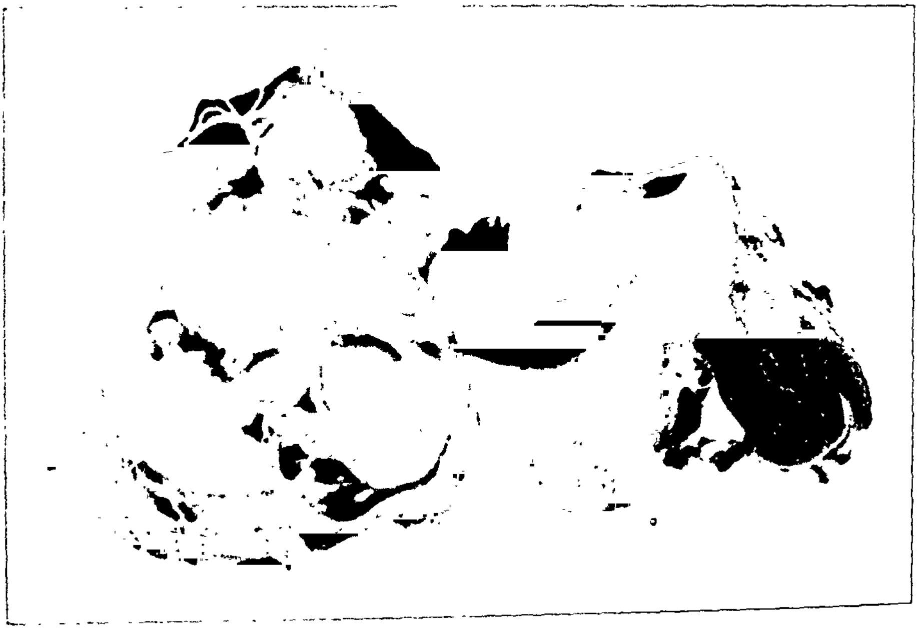

FIG. 1-A

Dog 3. Showing the extirpated meniscus and the newly formed disc (pseudocartilage). Note the degeneration of the articular cartilage of the femoral and tibial condyles (105 days).

FIG. 1-B

Dog 3. Showing femoral and tibial condyles. *A*: pseudocartilage; *B*: normal extirpated cartilage.

formed disc of fibrous tissue (Fig. 2-A). The internal tibial and femoral condylar articular surfaces had degenerated considerably (Fig. 2-B).

DOG 5

This animal was a very young puppy. The internal semilunar cartilage of the left knee was completely excised. Two hundred and eighty-seven days later there was complete regeneration, and only a very slight amount of articular cartilage degeneration (Fig. 3).

DOGS 6 AND 7

The posterior horns of the internal semilunar cartilages were excised. One hundred and fifteen days later there was complete replacement and considerable degeneration of the articular cartilage (Fig. 4).

DOGS 8 AND 9

The middle third of each internal semilunar cartilage was excised. Seventy-five days later the defects were well filled in and the articular cartilages opposite them were somewhat degenerated (Fig. 5).

DOGS 10 AND 11

The anterior third of each internal semilunar cartilage was removed. One hundred and twenty-five days later the defects were well filled in with the pseudocartilage. There was a moderate amount of degeneration of the articular cartilages (Figs. 6-A, 6-B and 6-C).

DOGS 12 AND 13

The internal halves of the medial semilunar cartilages were excised circumferentially (Fig. 7-A), in a manner similar to excision of the mesial fragment of a bucket-handle tear.

FIG. 1-C

Dog 3. Section through femoral condyle, showing degeneration of articular cartilage.

Ninety days later there was not the slightest evidence of false-cartilage formation (since the incision nowhere approached the synovial membrane) and only the very smallest amount of degeneration of the articular cartilages (Fig. 7-B).

DOGS 14 AND 15

A partial excision of the *external* semilunar cartilages was done. Ninety days later there was only the slightest formation of false cartilage and a moderate amount of degeneration of the articular cartilages. This lack of false-cartilage formation is exactly what one would expect from the anatomy of the external semilunar cartilage. In the dog's knee the common extensor muscle has a long intra-articular tendon of origin from the lateral femoral

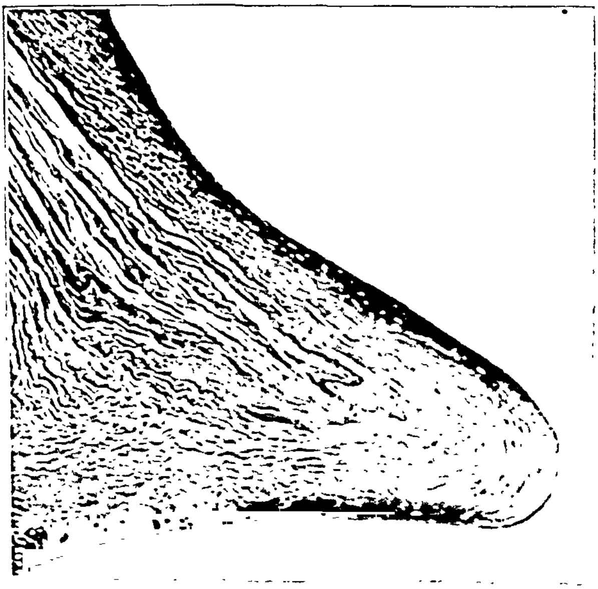

FIG. 1-D

Dog 3. Section through newly formed meniscus. Fibrous tissue only. No cartilage cells seen.

condyle. This tendon passes downward in a groove over the anterolateral surface of the external semilunar cartilage (*Fig. 8*). The lateral and posterior surfaces of the meniscus are grooved for the popliteus tendon, leaving very little surface for attachment to the synovial membrane. Since the false cartilage arises from an ingrowth of synovial membrane, at the point of its detachment from the semilunar cartilage, it is not difficult to understand its lack of formation in removal of the external semilunar cartilage.

FIG. 2-A

Dog 4. Showing excised portion of internal semilunar cartilage (left knee). Note newly formed disc (pseudocartilage) and degeneration of articular cartilage of tibia.

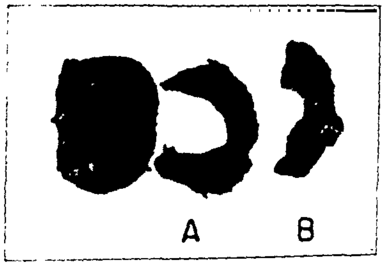

FIG. 2-B

Dog 4. Pseudocartilage, *A*, removed from tibial condyle. *B* is the original semilunar cartilage excised. At left is shown the articular surface of the internal tibial condyle.

FIG. 3

Dog 5. Very young puppy, 287 days after complete extirpation of the internal semilunar cartilage (shown at right). Note excellent pseudocartilage. There is very little degeneration of the articular cartilage.

FIG. 4

Dog 7. One hundred and fifteen days following excision of the posterior half of the internal semilunar cartilage. Starting at bottom, note: (1) degeneration of articular cartilage of medial femoral condyle; (2) degeneration of corresponding portion of medial tibial condyle; (3) articular cartilage intact peripherally; (4) perfect replacement of posterior half of semilunar cartilage; (5) excised portion.

FIG. 5

Dog 8. Left and right knees, 75 days after excision of middle third of semilunar cartilage. Excised fragments are shown between the knees. There has been complete replacement with pseudocartilage. Note moderate degeneration of articular cartilages opposite the original defects.

SUMMARY

In four joints the capsule was opened without disturbing the semilunar cartilages. No degeneration of the articular cartilages occurred (ninety days).

In four joints the anterior thirds of the internal semilunar cartilages were excised. The excised portions were replaced by an ingrowth of firm connective tissue from the synovial membrane, grossly not unlike fibrocartilage. *The articular cartilages of the tibial and femoral condyles were slightly degenerated* (125 days).

Similar changes were observed following removal of the middle (four joints) and the posterior thirds (four joints).

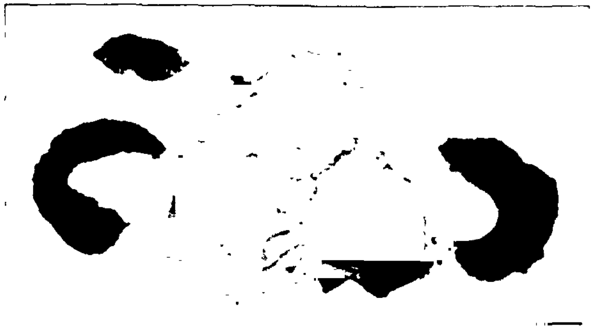

FIG. 6-A

FIG. 6-A

Dog 11. One hundred and twenty-five days after excision of anterior third of the internal semilunar cartilage. Note from left to right: *above*, the excised anterior third of the cartilage; *below*, the complete internal semilunar cartilage, showing how perfectly the excised portion is replaced by pseudocartilage; the internal tibial condyle showing degeneration of the articular cartilage; the external tibial condyle (normal); and last, at the far right, the normal external semilunar cartilage.

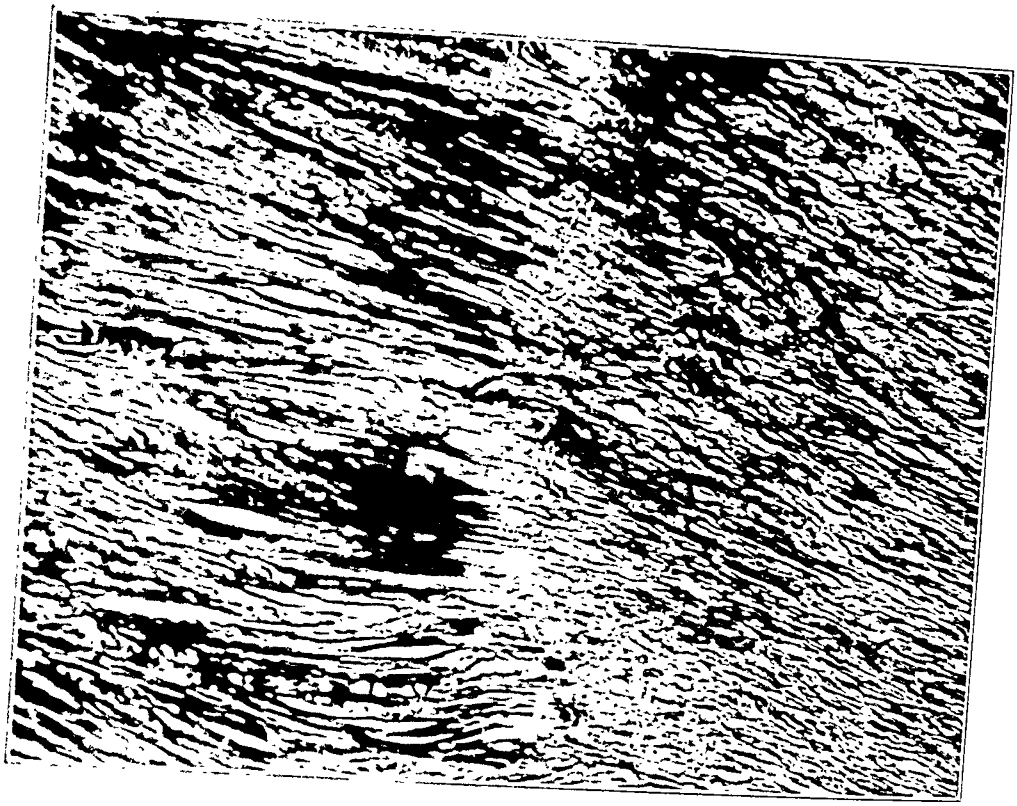

Fig. 6-B

Dog 11. Photomicrograph, showing abrupt transition from the normal fibrocartilage (left) to pseudocartilage (connective tissue) on right.

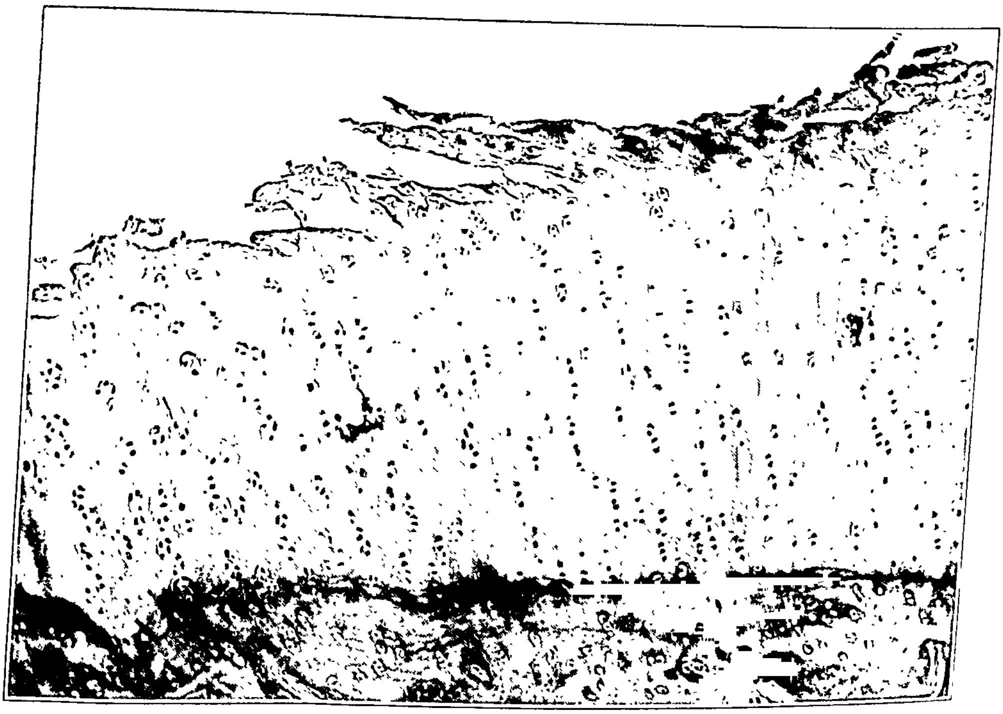

Fig. 6-C

Dog 11. Section through articular cartilage of medial femoral condyle. Note degeneration of superficial layers.

FIG. 7-A

Diagram illustrating operation done on Dogs 12 and 13. Dotted area indicates portion of semilunar cartilage removed.

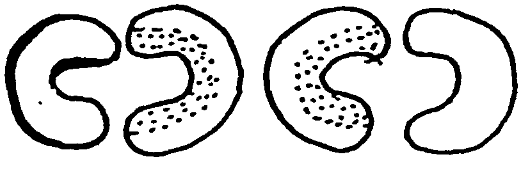

FIG. 7-A

FIG. 7-B

Dog 12. Ninety days after excision of internal halves of internal semilunar cartilages. Excised portion shown. There is no evidence of pseudocartilage formation and practically no degeneration of the articular cartilage.

When the internal semilunar cartilages were completely extirpated or subtotally excised (three joints) an excellent false cartilage was formed, but a severe degeneration of the articular cartilages took place (especially in the older dogs).

Partial excision of the external semilunar cartilages (four joints) was followed by articular-cartilage degeneration, but practically no false-cartilage formation.

There was no false-cartilage formation and very little articular degeneration following removal of the internal half of the medial semilunar cartilages (four joints).

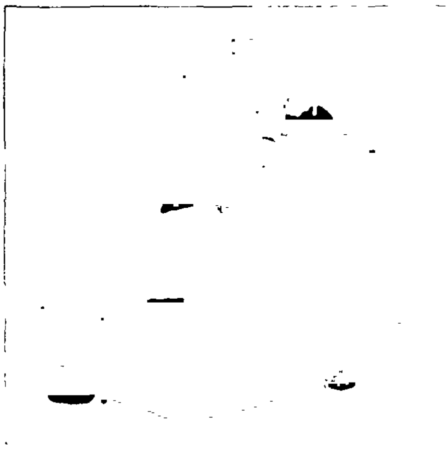

FIG. 8

External semilunar cartilage (right). Note groove anterolaterally and long groove for popliteus tendon.

CONCLUSION

When the internal semilunar cartilage of the dog's knee is extirpated, or a segment of it is excised, the resulting defect is filled in by an in-

growth of fibrous tissue from the synovial membrane. Grossly this newly formed tissue is indistinguishable from normal fibrocartilage. In spite of this replacement, considerable roughening and degeneration of the articular hyaline cartilages takes place. The amount of degeneration appears to be roughly proportional to the size of the segment removed, being greatest when a complete meniscectomy has been done. It also seems to be much less in young puppies than in older dogs. These findings indicate that the semilunar menisci serve to protect the articular hyaline cartilages, and that probably operative excision should be limited to removal of the mobile portion.

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DISLOCATION OF THE ELBOW REDUCED BY MEANS OF TRACTION IN FOUR DIRECTIONS

BY EDWARD H. CROSBY, M.D., HARTFORD, CONNECTICUT

New and easier methods of utilizing old and familiar principles already in use are of value. It is with this in mind that the author presents the following method of reducing dislocation of the elbow.

Regardless of the type of dislocation in an elbow, the reduction of the dislocation often causes considerable injury to the tissues around and in the joint. The method of four-direction traction minimizes injury to these tissues, thereby reduces the amount of postreduction swelling and pain, and, the writer feels, considerably shortens the period of convalescence.

Figure 1 shows the method of applying four directions of traction. The patient is placed on a stretcher with a folded sheet around the chest. The sheet is then tied or pinned to a cross-bar on the opposite side of the stretcher. This fixes the chest and gives countertraction. A four-inch muslin bandage, long enough to reach to the floor, is then placed around the arm above the elbow. This bandage is tied so that it forms a loop, the lower end of which is about six inches above the floor. The foot is placed in this loop for traction downward. A similar bandage is placed around the forearm with the elbow flexed at 90 degrees and is tied behind the operator. This gives traction laterally. The patient's wrist is grasped with the operator's left hand, thus producing traction upward, and the operator's right hand is free to manipulate the elbow joint.

FIG. 1

The patient is anaesthetized, and, when muscle relaxation has been reached, the operator gives traction in four directions by leaning backward, by pressing downward with the foot through the loop in the bandage, by pulling upward with the left hand, and with countertraction across the chest. The dislocation in the elbow joint is easily reduced by one operator with a minimum of injury to the joint.

The method described was suggested by the three-type-traction method of Dr. Merrill K. Lindsay.

AN UNUSUAL SHOULDER LESION

BY DAVID M. BOSWORTH, M.D., NEW YORK, N. Y.

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The following case of an unusual shoulder lesion was studied by the author in conjunction with several other surgeons. The only description of a similar lesion that could be found in the literature was that by Köhler.[1] In his book he states that the lesion is physiological and not to be looked upon as pathological, although such a configuration is rarely met with.

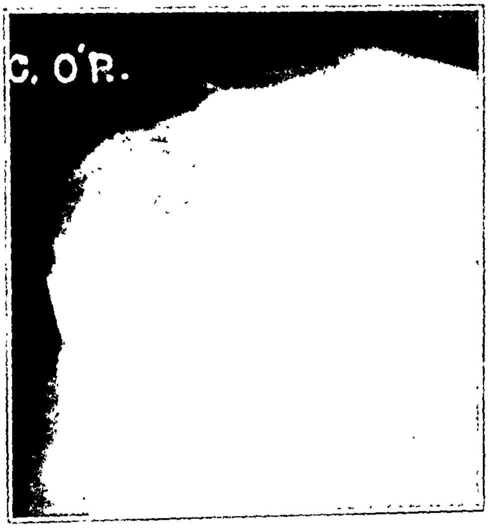

FIG. 1-A

Lesion in right humeral epiphysis.

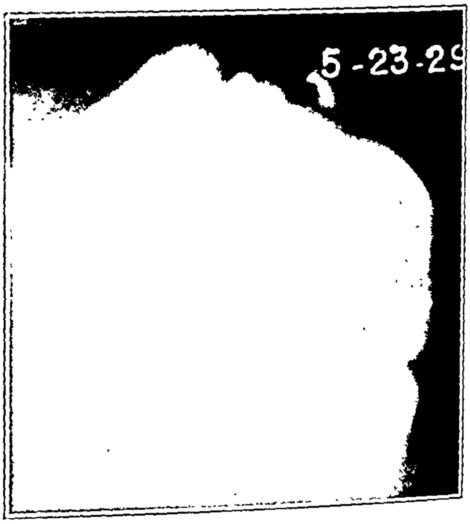

FIG. 1-B

Left humeral epiphysis, for comparison.

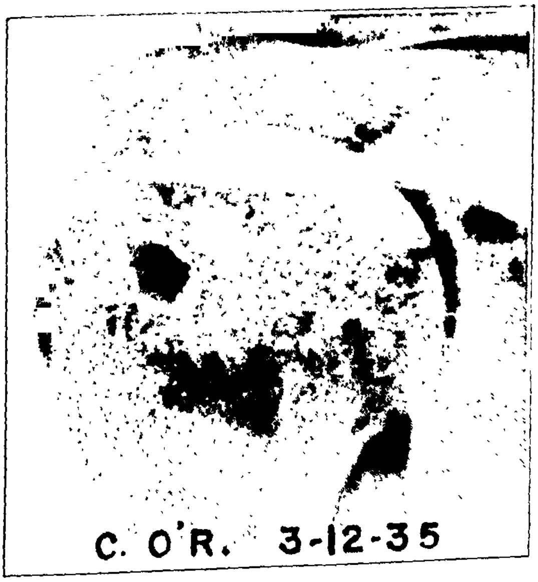

FIG. 2

Right humeral epiphysis six years later, without treatment or operative interference. Note dense area behind lower margin of abscess wall, which proved to be a sequestrum.

A boy, fourteen years old, was seen in March 1929 with a history of low-grade pain in the right shoulder of six years' duration, which had gradually become worse. The past history was negative for injuries, operations, or illness.

Examination showed a generalized limitation of motion in the shoulder, amounting to 20 per cent. in all directions, with spasm and protection of moderate degree. There was no swelling, crepitation, or external sign of pathology. No muscular atrophy of the shoulder girdle, arm, or forearm was present. A roentgenogram showed a raylike, coarsened structure of the greater tuberosity of the humerus as compared with the normal. (See Figures 1-A and 1-B.)

The case was diagnosed as an epiphysitis such as is found in the tibial

Fig. 3

Photomicrograph through the sequestrum, showing dead bone without cells and amorphous deposits about it with inflammatory soft-tissue reaction.

tubercle and in the head of the femur, and drilling for new blood supply and biopsy was advised, but was refused.

The patient disappeared and returned six years later in March 1935. The symptoms had continued in the interim, becoming worse during the two months prior to his return. Examination revealed essentially the same conditions as had been found six years before. However, a roentgenogram (Fig. 2) showed within the base of the greater tuberosity a pocket which contained a small sequestrum. At operation, March 22, 1935, a sequestrum was found lying in granulation tissue. Sections of this showed bone without living cells, degenerating on the margins into amorphous material. (See Figure 3.)

The lesion described has been considered in the past as an epiphysitis. In the present case, however, such a lesion, after six years, was found to have caused sequestration which resembled a localized osteomyelitis.

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LOCKING OF THE HIP JOINT DUE TO OSTEOCHONDROMA OF THE LESSER TROCHANTER

BY DAVID POVERMAN, M.D., NEW YORK, N. Y.

Senior Resident Orthopaedic Surgeon, Hospital for Joint Diseases

This case is considered worthy of presentation because of the extreme rarity of the presenting symptom. A careful search of the English literature reveals very few cases of locking at the hip joint and no case in which locking was due to a tumor. Of course, cases are frequently reported in which there is limitation of motion due to actual obstruction.

The patient, No. 56287, female, aged twenty-seven, was admitted to the Service of Dr. Samuel Kleinberg on December 3, 1935. Her chief complaints at this time were weakness of the right lower extremity of five years' duration, pain in the right groin of one year's duration, and locking of the right thigh at the hip joint (six attacks in eight months).

The patient stated that she had been perfectly well until five years before admission, when she had first begun to notice a weakness of the right lower extremity which was aggravated when she walked more than usual or when she operated the brake of her car. The symptoms at this time were not of sufficient severity to cause her much concern. The symptoms had increased very gradually and four years later she had found it difficult and painful to walk fast or for long distances. During the eight months prior to admission she had found on six occasions that her hip had locked in extension. Each time that this had occurred she was lying in bed and suddenly found that she was unable to flex the right thigh. After a series of motions, which usually consisted of internal rotation and attempts at flexion, the thigh perceptibly unlocked and motion at the hip joint was again free.

The patient had had scarlet fever, diphtheria, and pneumonia in childhood. She had had two tonsillectomies and a fracture of the right wrist. Her father had died of pneumonia at the age of thirty-one and her mother had died of cardiorenal disease at forty-nine. There were no siblings.

Examination showed that the patient was in

FIG. 1

Preoperative roentgenogram of osteochondroma of the lesser trochanter of the right hip.

excellent condition. She walked without assistance and without a limp. The length and circumference of the lower extremities were equal. The range of motion of both hip joints was free and normal. Locking could not be elicited by manipulation. On the internal aspect of the right thigh, just below the groin, there was an area of slight tenderness to pressure, and a sense of resistance was palpable, rather than a distinct mass. The remainder of the examination was negative.

Roentgenographic examination showed a large osteochondroma occupying the region of the lesser trochanter and extending upward and inward toward the hip joint.

At operation on December 4, 1935, a six-inch incision was made over the anterior aspect of the right thigh. The sartorius was retracted medially and the tensor fasciae femoris was retracted laterally, exposing the underlying rectus femoris. The fibers of this muscle were split longitudinally and, after some little effort, the anterior aspect of the femur was brought into view. This was cleared subperiosteally, exposing the region of the lesser trochanter. Here was found a large mass, three and five-tenths centimeters in vertical diameter, extending inward and upward from the inner aspect of the shaft of the femur. This mass was very irregular and really consisted of two parts,—an anterior bony and a posterior cartilaginous portion. Between these two masses there was a deep groove, and overlying this was a long aponeurotic fibrous cord, about five-tenths of a centimeter in diameter, extending from the region of the iliopsoas above to the inner lip of the linea aspera below. This cord was very tense and evidently its dislodgement into the groove on the anterior aspect of the tumor was the cause of the locking. This aponeurotic cord was cut, giving easier access to the bony mass. With a chisel, the exostosis was split vertically at its junction with the femur. The exostosis was removed with considerable difficulty because its posterior aspect was adherent to the surrounding periosteum and muscle.

FIG. 2

The excised tumor, showing the groove in which locking was produced.

The postoperative course was essentially uneventful. The wound healed *per primum* and the patient was up and walking on the twelfth postoperative day. She has since been well and has had no recurrence of symptoms.

BILATERAL GIANT MENISCUS

A Case Report

BY MAURICE H. HERZMARK, M.D., NEW YORK, N. Y.

Since there have been only a few cases of a similar nature recorded in the literature, the following case of bilateral giant meniscus is reported.

M. L., a white male, aged fifteen years, was admitted to the Hospital for Joint Diseases on the Service of Dr. S. Kleinberg on July 5, 1932, with a history of pain and clicking of the left knee. The onset of this condition had occurred about two and one-half months prior to admission, with no trauma.

On admission, the patient walked without a limp, but motion of the left knee caused a clicking sound. There was slight pain on pressure over the external line of the joint, and a palpable mass presented on flexion of the joint. The right knee joint showed a similar but less marked condition. Roentgenographic examination revealed no pathology.

On July 8, 1932, under general anaesthesia, and with the use of an Esmarch bandage, the left knee joint was opened through an external parapatellar incision. The external semilunar cartilage covered the entire outer tuberosity of the tibia and extended into the fatty tissue in front and laterally. The entire cartilage was removed, together with a part of the fat pad. The joint was closed in the usual manner and immobilized.

FIG. 1

External semilunar cartilage, showing discoid appearance rather than normal semilunar shape. The ridges are caused by the clamp.

The gross specimen consisted of external semilunar cartilage with part of the capsule and a small piece of the fat pad. The cartilage was gigantic, measuring two and seventy-five hundredths centimeters in width and four centimeters in diameter.

Microscopic section showed a very large semilunar cartilage. There had been some degeneration, causing the tissue to stain poorly and to separate into strands. The synovia had undergone villous hypertrophy and vascularization.

The patient made an uneventful recovery with relief from pain and clicking in the knee which was operated upon.

On October 9, 1935, this patient was re-admitted to the Hospital for Joint Diseases because of a clicking on motion of the right knee. Examination on admission showed no limp but a distinct clicking on flexion of the right knee, and a palpable mass over the external semilunar cartilage. The left knee was free from pain or clicking. Because of the experience with the left knee a diagnosis of giant meniscus could now be made.

On October 10, 1935, an arthrotomy, similar to that done on the left knee, was performed on the right knee joint. A very large external cartilage was seen covering the entire external tuberosity of the tibia. There was no marginal thickening, the cartilage being continuous with the transverse ligament. This cartilage was removed *in toto*.

Fig. 2
Microscopic appearance, showing the degeneration and fibrous nature of the tissue.

The gross specimen consisted of a large external semilunar cartilage, three and five-tenths centimeters by three centimeters.

Microscopic section showed mucoid degeneration and young cartilage cells in shreds.

The patient made an uneventful recovery with complete relief from symptoms.

HANDY BONE-GRASPING FORCEPS

BY CHARLES K. PETTER, M.D., OAK TERRACE, MINNESOTA

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In the carrying out of thoracoplasties of various types, it has been found desirable at times to have bone-grasping forceps with which to hold firmly ribs which are being stripped from a densely infiltrated or adherent periosteal bed. On other occasions in orthopaedic work, such as holding an Albee graft for shaping, the usual Ferguson lion-jaw bone-grasping forceps have not proved adequate, nor have the large Kocher forceps been capable of holding the graft without springing or permitting the graft to slip. As a result, the bone-grasping forceps shown in Figure 1 (left) were designed by the author and produced in the machine shop at Glen Lake Sanatorium.

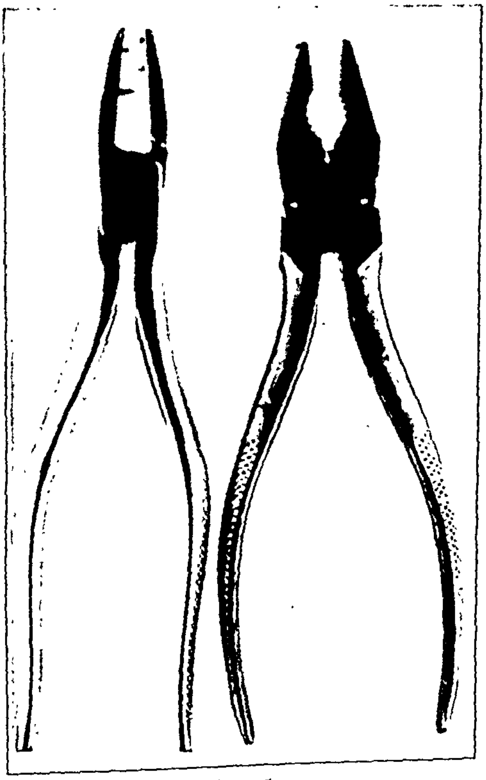

FIG. 1

Broad-nosed heavy-duty pliers, shown in Figure 1 (right), were ground down on an emery wheel, so that the head and nose of the pliers took on the shape shown on the left side of the photograph. The shape of the handles was changed by forging, and several small teeth were set into the jaws as illustrated. Two teeth were placed toward the extremity of one jaw and the other teeth were set in the other jaw nearer the center. The teeth vary in length to allow the firm grasp of even a very thin rib when the forceps are closed. The pins or teeth were made from small twist drills and were forced into drill holes in the jaws of the forceps, after which they were sharpened with a file.

These forceps have been found extremely useful in handling ribs and bone grafts which were either too small to be held securely by the Ferguson lion-jaw forceps or too large to be held firmly by the large Kocher forceps. They have the added advantage over the Ferguson lion-jaw forceps of possessing a rather slender nose, so that they can be used in close quarters.

This instrument can be constructed by a capable machinist at a relatively small cost and, after being plated, makes a valuable addition to the orthopaedic surgeon's equipment.

The author is indebted to Mr. Allen Dean for his technical assistance in constructing this instrument.

AN INSTRUMENT TO AID IN THE REDUCTION OF BENNETT FRACTURES

BY OTHO C. HUDSON, M.D., F.A.C.S., HEMPSTEAD, NEW YORK

The difficulty of obtaining reduction in Bennett's fractures, and of maintaining reduction if it is obtained, prompted the development of this instrument. The illustration shows a glorified towel clip which has since been perfected and has a removable box lock.

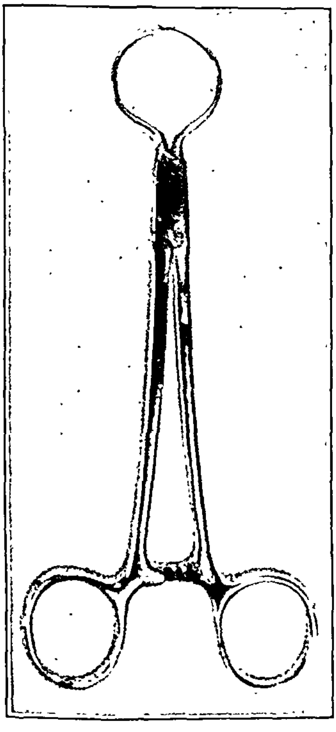

Fig. 1

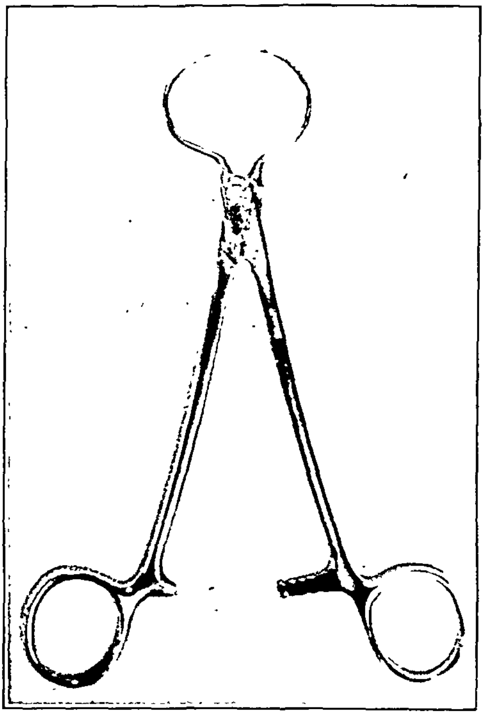

Fig. 2

The instrument is inserted through the skin into the head of the metacarpal bone with the tongs. After this has been done, traction and abduction are easily obtained by means of skeletal traction, so that anatomical reduction is the rule and not the exception. Plaster is then applied from the tip of the thumb to the elbow, maintaining the thumb in complete abduction and the wrist in slight dorsiflexion. The plaster extends through the web of the thumb to the metacarpophalangeal joint of the forefinger, in order to maintain the abduction.

This instrument has been used in twelve cases, in each of which perfect reduction has been maintained.

SAMUEL R. CUNNINGHAM

Dr. Samuel R. Cunningham, a member of the American Orthopaedic Association since 1932, died at a hospital in Oklahoma City on September 7, at the age of sixty-four. He had done important work in orthopaedic and industrial surgery for many years.

Dr. Cunningham was born on a farm in Putnam County, Indiana, July 20, 1872. He received his professional training at the Medical College of Indiana at Indianapolis, receiving his medical degree from that institution in 1899. He remained in Indianapolis for the next ten years, serving as a member of the faculty of the school from which he was graduated.

In 1909 he moved to Oklahoma City, where he lived and practised until the time of his death. During the last ten years he was Professor of Orthopaedic Surgery in the University of Oklahoma. He was also Orthopaedic Surgeon at St. Anthony's Hospital, Chief of the Orthopaedic Staff of the University Hospital, and Chief of the Orthopaedic Staff of the Crippled Children's Hospital.

In addition to his membership in the American Orthopaedic Association he also held membership in the Oklahoma County Medical Society, the Oklahoma State Medical Association, and the American Medical Association. He was a Fellow of the American College of Surgeons and of the American Academy of Orthopaedic Surgeons.

During his residence in Indianapolis, he attended James Whitcomb Riley. This experience led to an interesting incident on the occasion of the visit of the American Orthopaedic Association to the British Orthopaedic Association in England in 1929. At a dinner given in Liverpool by Sir Robert Jones, Dr. Cunningham recited James Whitcomb Riley's poem "The Little Cripple", to the great delight of Sir Robert.

Dr. Cunningham was a loyal supporter of the American Orthopaedic Association and his friends will always remember his genial spirit at the meetings and his efforts to make them a success. Although far from well, he went by plane to Milwaukee in order that he might attend the Annual Meeting of the Association last May.

He is survived by his wife, Mrs. Della H. Cunningham, and by two sons by a former marriage, one of whom, Hugh, is a surgeon in New York City. Dr. John Cunningham of Indianapolis is a brother.

Funeral services were conducted in Oklahoma City on September 10, with Dr. W. K. West representing the American Orthopaedic Association.

News Notes

Readers of *The Journal,* who have appreciated the valuable contributions of **Dr. Max Böhm** published in the pages of *The Journal,* will be sorry to hear of his death in Berlin on April 26, 1936.

Dr. Böhm was born in Ratibor on December 17, 1878. He received his orthopaedic education in the mechanotherapeutic institution of the University of Berlin, the Massachusetts General Hospital, Boston, Harvard University, and in Hoffa's Clinic in Berlin. He early showed peculiar scientific ability and inclination with a preference for etiological research.

This research work resulted in a long series of valuable articles which set forth through painstaking and detailed anatomical studies the development of human limbs and joints and sought to explain the origin of deformities on the basis of this development. Perhaps particularly worthy of note are the works which deal with the varieties in the structure of the vertebral column, published early in his scientific career. To his experience during the War we owe a number of valuable publications dealing with the subject of prostheses.

While he was connected with the Massachusetts General Hospital he installed and taught the use of the Zander apparatus.

From 1925 until 1933 he was Director of *Krüppelfürsorgestelle* (Institution for the Care of Cripples) in Charlottenburg.

Dr. Böhm was a member of the Deutsche Orthopädische Gesellschaft and was also elected Honorary Member of the British Orthopaedic Association in 1933.

The Annual Meeting of the **British Orthopaedic Association** will be held in London on October 30 and 31, 1936, under the presidency of Mr. W. R. Bristow.

Walter P. Blount, M.D., and Robert P. Montgomery, M.D , announce their association in the practice of bone and joint surgery, with offices at 324 East Wisconsin Avenue, Milwaukee, Wisconsin.

The Congress of Railway Surgeons will meet in their Forty-Seventh Annual Convention at the Palmer House, Chicago, November 5 to 7. Many associations of railway surgeons participate in this Annual Convention.

In recognition of his long and remarkable service to orthopaedic surgery and of his devotion to the work of ameliorating the condition of the crippled child. Prof. Henry Turner of Leningrad has just been honored by the Soviet Government by being made a member of the Military Order of the Red Star. His many friends will be glad to know of this testimonial, which is so well deserved.

At a meeting of the **American Board of Orthopaedic Surgery**, held at Kansas City in May, sixty candidates were examined and Certificates were granted to forty-six. The next examination by the Board will be held at Cleveland on January 9, 1937, just preceding the meeting of the American Academy of Orthopaedic Surgeons. Applications should be sent to the Secretary, Fremont A. Chandler, M D., 180 North Michigan Avenue, Chicago, Illinois.

The Sixty-Fifth Annual Meeting of the **American Public Health Association** will be held in New Orleans, Louisiana, October 20 to 23. An interesting and constructive program, dealing with many phases of public health, has been arranged. Additional information may be obtained from the Association's office, 50 West 50th Street, New York City.

The Fifth Annual Convention of **The American Academy of Orthopaedic Surgeons** will be held in Cleveland, Ohio, January 10 to 14 inclusive, 1937, with headquarters at the Hotel Cleveland.

The program will include scientific papers, seminars, scientific exhibits, and technical exhibits. There will be some distinguished foreign members present.

Some of the outstanding presentations will include seminars on: "The Lesions of the Shoulder Joint", by Dr. E. A. Codman; "Low-Back Lesions", by Dr. Joel Goldthwait; and "Osteomyelitis", by Dr. H. Winnett Orr. Dr. Howard Lewis, a guest, will present a paper on "Sulphur Metabolism in Relationship to Arthritis". Dr. Charles Huggins of the University of Chicago will present a paper on "Red Bone Marrow", and Dr. H. Wingate Todd, on "Normal Bone Growth". There will be a symposium on "Tuberculosis of Bones and Joints", including the following papers: "The Location of the Original Lesion", to be presented by Dr. Dallas Phemister; "Pott's Disease", by Dr. Edwin F. Cave; and "Roentgenology", by Dr. A. B. Ferguson.

REPORT OF THE CONGRESS OF THE LIGUE INTERNATIONALE CONTRE LE RHUMATISME

LUND AND STOCKHOLM, SEPTEMBER 3 to 8, 1936

The Congress opened in the auditorium of the University of Lund. Prof. Sven Ingvar, President of the Congress, welcomed the members to Lund. Dr. R. Fortescue Fox of London, President of the *Ligue*, and Dr. J. van Breemen, the Secretary, spoke of the objects of the *Ligue* and of the Congress. Greetings were given by representatives of Sweden, Russia, France, Germany, Hungary, and the United States. The program of this Congress, under the extremely expert management of Dr. G. Kahlmeter (Stockholm), was divided into four subjects.

I. Allergy in Rheumatic Diseases

Among a few of those reporting were: Prof. Klinge (Münster), Prof. Konchalovski (Moscow), Dr. Freeman (London), Dr. Weil (Paris), Dr. Dawson (New York), Prof. Pletreur (Moscow).

Although infection was considered the probable cause of rheumatism, many believed that the theory of allergy furnishes a basis for a scientific conception of rheumatism, because humoral modifications may result, which play the part in the blood of partial antigens and which may, because of acquired or inherited sensibility, call into being certain pathological anatomical irregularities in organs and joints.

The hypothesis of allergy does not explain the etiological factor, but it has increased our knowledge of the pathogenesis. Up to the present, the allergic nature of rheumatism has not been proved. Our present knowledge makes us assume that it is probable that specific rheumatism is of bacterial origin, but that during the course of the disease allergic reactions play an important rôle.

II. The Reading of X-Ray Photographs in Arthritis

Dr. Scott (London), Dr. Hellmar (Lund), Dr. Vontz (Bad Neuenahr), Dr. Weil (Paris), and Dr. Blaveck (Praha) were among the speakers.

More careful roentgenographic study of rheumatism was considered imperative for differential diagnosis, not only between other diseases (Paget's disease, cancer, gout, etc.), but especially between the different types of arthritis. X-rays alone probably cannot give the etiological factors or the prognosis, but standardized x-rays, preferably serial roentgenograms of the hand, give very accurate data. The general opinion

seemed to be that ankylosing spondylitis began very early in the sacro-iliac joints; according to Scott this was due to infection, and in turn acted as a focus of infection. It occurred before any symptoms brought the patient to the doctor. The opinion was general that more careful observation of the x-rays was needed to distinguish the early changes in bone; this might help us to understand the pathology better.

The opinion was expressed that x-ray treatment, as advised by Dr. Kahlmeter (Stockholm), was of definite benefit in inflamed joints.

III. The Nature of Myalgia

Prof. Ingvar (Lund), Dr. Freund (Wien), Dr. de Pap (Budapest), and Dr. Burt (Bath) spoke.

Myalgia is apparently neither a true neuritis nor neuralgia, but is a pain reaction due to inflammation in the muscles. It is caused by fatigue, cold, moisture, atmospheric pressure, acute or chronic strain, trauma, infections, disturbed metabolism, and physically depressive factors in a supersensitive person. Usually there is an inherited predisposition.

There are three main symptoms: pain, muscular contraction, and palpable infiltration or nodules. The blood circulation is disturbed in all cases, resulting in temperature changes which can be measured. This gives the indication for treatment to restore circulation. The causes of this change may be toxic and bacterial poisons. General factors determine the time for the appearance of symptoms. Localizing factors may escape notice because of their insignificance.

IV. The Help the Orthopaedic Surgeon Can Give in the Treatment of Chronic Arthritis

Prof. Haglund (Stockholm), Dr. Swaim (Boston), Prof. Kahlmeter and Prof. Hybbinthe (Stockholm), Dr. Horvath (Budapest), Dr. Weissenbach (Paris), and Dr. Kersley (Bath).

There was general agreement that orthopaedic care was necessary in the very beginning of rheumatism. Complete rest in plaster was essential to the prevention of deformities and to reduce the inflammation in the joints. The dangers of ankylosis were decreased by early protection.

General posture was important for the relief of joint strain and return to physical vitality. Manipulation was not encouraging, but reconstructive operations were indicated only when the disease was quiescent. Capsuloplasties, synovectomies, arthrotomies, and arthoplasties were the operations of choice.

The cooperation between the medical and orthopaedic departments of the hospital at the beginning of the disease in every case was urged.

Sunday, September 6, was a day of sightseeing and on Monday, September 7, the Congress continued in Stockholm, where still another subject was considered.

V. The Housing Conditions in Rheumatism

Careful studies of the housing conditions in England and Sweden suggest very strongly that, although rheumatic fever, Still's disease, and arthritis are probably infectious in origin, the damp, cold houses, especially along rivers and in wet regions, tend to increase the difficulties in getting well, and chronic conditions result. A dry, well-drained soil seems best for recovery.

Hospital treatment in Sweden has shown encouraging results. The new Lund Hospital affords an excellent example of the *Invalid Insurance System*, which guarantees expert care to all patients at the minimum of expense to them. The equipment is of the latest and the hospitals are the property of the community, which pays part of the expense of each patient.

The Congress was well attended. Approximately 200 of the leading "Arthrologists" from most of the countries of the world took part in the discussions.

The *Ligue Internationale contre le Rhumatisme* is to be congratulated on its excellent program and the valuable work it is doing in promoting interest in and study of all forms of rheumatism.

Loring T. Swaim, M.D., Boston, Massachusetts

Current Literature

TUMORS OF BONE. (Including the Jaws and Joints.) By Charles F. Geschickter, M.D., and Murray M. Copeland, M.D. With Forewords by Dean Lewis, M.D., and the late Joseph Colt Bloodgood, M.D. Revised Edition. New York, *The American Journal of Cancer*, 1936. 832 pages. $6.00.

A revised, second edition of this text, first issued in 1931, has been necessitated by progress in the knowledge of osseous tumors in the past five years and the desirability of making the work more complete by the addition of three sections on specialized tumors in tendon sheaths, bursae, joints, and the jaws and cranial bones. Also there have been additions to the section on bone diseases other than tumors.

The illustrations are excellent and are better than those of the first edition, and several skeletal charts are included which are made to show graphically the common localization of the various tumors throughout the body.

Coming as it does from the Laboratory of Surgical Pathology at Johns Hopkins University, made famous by the work of the late Dr. Joseph Colt Bloodgood who wrote a foreword, itself an important part of the book, its value as an authoritative statement of present-day knowledge of tumors of bone is practically guaranteed. Clearly written, well documented, and carefully arranged and indexed, it is adapted to the practitioner's needs as well as to the needs of those more particularly concerned with the pathology of this type of disease.

The keynote of the authors' approach to their subject is the endeavor to demonstrate the relationship of osseous tumor formation to osteogenesis. For the most part, it is at the periods of transition from one stage in bone formation to another that the various types of osseous tumor arise. Viewed from this standpoint, the study of osteogenetic tumors is vastly more interesting than before this clue to their investigation was discovered. This knowledge divides the field of osteogenetic tumors into two main divisions, *viz.:* Part I includes those lesions derived from precartilaginous connective tissue and those which are the result of growth subsequent to chondrification. A second class, Part II, embraces tumors of non-osseous origin,—*e.g.*, (1) primary lymphoma of bone, (2) multiple myeloma, (3) metastatic carcinoma, and (4) fibrosarcoma and neurogenic sarcoma. Following the extended consideration of the above classes is a discussion of osseous changes in the hemopoietic system, among which are the granulomata, lymphosarcomata, leukemias, and the rarer diseases of Gaucher, Christian, and Niemann-Pick.

Part III, which is entirely new in this edition, is devoted to tumors of the cranium, the jaws, the synovial membranes, tendon sheaths, and bursae, and is a very valuable supplement to the consideration of the subject of bone and joint pathology.

The final three chapters, constituting Part IV, are devoted to differential diagnosis, juvenile lesions in bone, and a brief but suggestive chapter dealing with therapeutic measures and the fields in which they are applicable.

No one interested in the pathology of bone or the clinical manifestations to which such pathology is related should be without this book.

DIE WIRBELGELENKE (The Intervertebral Articulations). By Prof. Dr. Max Lange. 2 Aufl. Stuttgart, Ferdinand Enke, 1936. 10 marks.

This monograph, dealing solely with the intervertebral articulations, opens another door to the exact diagnosis of many puzzling orthopaedic problems. Schmorl and Junghanns, to whom we are indebted for much of our knowledge of special pathology, indicated the need for this study in their volume "The Normal and Pathological Spine

in the Roentgenogram". There they wrote: "Extensive research must be undertaken before even a degree of clarity can be imparted to our knowledge of the intervertebral joints." This research has been done by Max Lange with the thoroughness typical of the Munich Orthopaedic Clinic.

The first chapter describes the appearance of the normal intervertebral joints and the x-ray technique used. The oblique views are all-important. In the lumbar region, less distortion occurs if the lordosis is corrected by flexing the hips. Reproductions of roentgenograms are given, showing the change in the appearance of the joints during flexion, extension, and lateral bending.

The major portion of the book treats of the pathological joint changes in such conditions as scoliosis, kyphosis, tuberculous spondylitis, arthrosis deformans, vertebral fractures, spondylolisthesis, and "lumbago". As material the author had access to the Schmorl collection of spines and to several thousand roentgenograms of the Munich Clinic. Of the many interesting facts brought out by this study, the following are among the more significant:

1. There is no relationship between the changes in the bodies of the vertebrae (spondylosis deformans) and changes in the intervertebral articulations (arthrosis deformans).

2. Vertebral fractures with compression of the bodies cause definite changes in the intervertebral articulations, and these changes, with compression of the adjacent nerve foramina, are probably responsible for the persistence of pain in the unreduced fractures of the spine.

3. Spondylarthritis ankylopoetica is a rare disease, only twelve cases having been discovered in the Munich Clinic in recent years.

4. Pathological changes in the lumbosacral articulations were found frequently in young as well as in older individuals and are unquestionably one of the important causes of low-back pain.

The book is illustrated with excellent reproductions of roentgenograms. It is a volume which will appeal to all physicians eager to understand more about the causes of back pain.

THE OPERATIONS OF SURGERY. By R. P. Rowlands and Philip Turner. Ed. 8. Volume I. The Upper Extremity, the Head and Neck, the Thorax, the Lower Extremity, and the Vertebral Column. Baltimore, William Wood & Co., 1936. 1045 pages. $10.00.

Rowlands died before this new edition was finished. It was completed by Turner with the assistance of Messrs. Ogilvie, Massie, Thompson, and Gibberd. This system of surgery has been developing since 1889, when it was started by Jacobson. All of the best parts have been retained and augmented, the obsolete have been eliminated, and much of the new surgery has been added.

The examination and preparation of the patient is considered first. There is a general discussion of factors of importance,—the preparation of the patient, the selection of the anaesthetic, the position of the patient on the table, methods of combating shock, and postoperative complications. The usual methods of transfusion, infusion, and skin-grafting are reviewed.

This volume should be of especial interest to the orthopaedic surgeon. Hundreds of pages are devoted to operative treatment of the spine and of the extremities. Many methods of accomplishing a result are given, with emphasis on the method which seems to be the best. Many of the operations are illustrated.

The abstractor was unable to detect the omission of any important operation on these regions. The scope of the book is wide. The treatment of the subjects is concise and interesting, and the subjects have been brought up to date. If the other volumes keep up to this same standard, the entire treatise will be one of the best in surgical literature.

RÖNTGENDIAGNOSTIK DER KNOCHEN- UND GELENKKRANKHEITEN (*Roentgenographic Diagnosis of Bone and Joint Diseases*). By Prof. Dr. Robert Kienböck. Heft 4. Degenerative Wirbelsaulenerkrankungen (*Degenerative Lesions of the Spine*). Berlin and Vienna, Urban & Schwarzenberg, 1936. 24 marks.

The fourth volume of the series, a little more bulky than the preceding ones, is made up largely of 120 case reports with reproductions of roentgenograms. The degenerative lesions of the spine are grouped as: (1) adolescent kyphosis (Scheuermann); (2) deforming spondylarthrosis, the hypertrophic changes of advancing age; and (3) porotic kyphosis, usually only the local manifestation of a generalized osteoporosis. The condition last mentioned may appear in childhood with the development of poor posture or even severe kyphoscoliosis. Under the second group are discussed lumbosacral pain, spondylolisthesis, and hemangioma. The grouping is rather arbitrary.

There is much interesting and valuable material in this volume. The lack of captions for the illustrations and the absence of any index make it rather inaccessible.

ORTHOPAEDIC SURGERY. By Walter Mercer, M.B., Ch.B., F.R.C.S. (Edin.). With a Foreword by John Fraser, M.C., M.D., Ch.M., F.R.C.S. (Edin.). Ed. 2. Baltimore, William Wood & Co., 1936. $10.00.

Up-to-date textbooks of orthopaedic surgery in English are not numerous and this second edition of Mercer's will probably be well received. Its 906 pages include excellent descriptions of orthopaedic disabilities, both rare and common. The treatment of fractures and other traumatic injuries to muscles, bones, and joints has been omitted. There is, however, a good chapter entitled "Some Complications of Trauma" in which is discussed Volkmann's contracture, myositis ossificans, delayed union, malunion, and non-union.

The subject matter is presented in a clear, orderly fashion and the illustrations are numerous and valuable. As a descriptive text, the book is equal or superior to most of its contemporaries. The author has attempted to bring the treatment of the various orthopaedic disabilities up to date by reviewing the recent literature of the field and incorporating the newer methods which he considers valuable. American contributions receive a good deal of attention. In many places, the author has freely stated his preferences as to method of treatment, thus avoiding the dry, impersonal, judicious presentation of other texts.

The author's point of view, as Fraser states in the foreword, is that of the general surgeon who is particularly interested in orthopaedics. Students and general practitioners will find this a readable, practical reference work though the specialist in orthopaedic surgery will probably not agree with the author on various points of treatment.

MINOR SURGERY. By Frederick Christopher, S.B., M.D., F.A.C.S. With a Foreword by Allen B. Kanavel, M.D., F.A.C.S. Ed. 3. 1030 pages with 709 illustrations. Philadelphia and London, W. B. Saunders Co., 1936. $10.00.

In this third edition the old sections have been amplified and brought up to date. The chief additions are on fracture healing, cleansing of wounds, antiseptics, snake bites, treatment of burns, electric shock, varicose veins, head injuries, compression fractures of the spine, acromioclavicular separation, pilonidal sinus, blood transfusions, and the treatment of ileus.

New material deals with new methods for promoting wound healing, bacteriophage, resuscitation upon the operating table, de Takats' method of ambulatory vein ligation, effort thrombosis, leech treatment of phlebitis, x-ray treatment of gas gangrene, bismuth injection treatment of warts, sodium morrhuate in cystic hygroma, "sprinter's fracture", lymphogranuloma inguinale, Elliott's treatment of pelvic inflammatory disease, torus fractures, glomus tumors, iliopectineal bursitis, Leriche's treatment of sprains, aspiration biopsy, Wangansteen stomach-suction apparatus, etc.

It is surprising how large is the field of "Minor Surgery". However, the author has carefully avoided more than the brief mention of the major surgical procedures. The subjects which he has selected are those usually treated in a physician's office or in a clinic.

One of the best chapters is that on "The Surgical Intern". This could well be read by all interns as well as by the fully qualified surgeon. Much is taught the intern in regard to the care of the patient before, during, and after both minor and major operations.

This is one of the most complete as well as up-to-date books on minor surgery that has been published. It is thoroughly recommended to all surgeons.

VASCULAR DISORDERS OF THE LIMBS. By Sir Thomas Lewis, C.B.C., F.R.S., M.D., D.Sc., L.L.D., F.R.C.P. (London). New York, The Macmillan Company, 1936. $2.00.

This volume is the ninth of a series by the same author on the heart and blood vessels and is directly supplementary to his monographs on "Diseases of the Heart" and "The Blood Vessels of the Human Skin and Their Responses". It is based upon his clinical research and that of his colleagues in the University College Hospital, London, during the past nine years, within which time notable progress has been made throughout the world in the knowledge of disorders of the peripheral circulation.

Although this advance has included important contributions to the understanding and treatment of phlebitis, varicose veins, and aneurysm, the author has excluded these three principal topics from his present consideration, because their inclusion, as the most familiar of the vascular disorders, would unduly increase the size of his book and distract attention from the more important considerations which he has to bring forward. He describes the functions and control of the circulation in the extremities and the methods by which the blood-flow rate, the vascular capacity, and the vasomotor nerves may be tested. He describes the effects of circulatory arrest, both temporary and permanent, and the anatomical phenomena of collateral circulation following the occlusion of the main arteries. In a series of chapters he describes the symptoms, course, and treatment of embolism and thrombosis of the main arteries; of post-ischaemic contractures; of intermittent claudication; of arteriosclerosis; of thrombo-angiitis obliterans; of local arterial spasm in ergot poisoning, impact, disuse, and cold; of Raynaud's disease; of gangrene associated with cervical rib; of vasodilatation; and of vascular disorders in diseases of the nervous system.

All these conditions are described for practitioners and students, the book being essentially clinical in its purpose. Clearly, these vascular phenomena are matters of interest and importance to the orthopaedist since their presence may complicate or even simulate various orthopaedic conditions which come under his consideration. The book is brief and extremely well written and readable, though without illustrations.

ZUR ERKENNUNG UND BEGUTACHTUNG VON SCHÄDELGRUNDBRÜCHEN. By Hans Hellner. (Heft 19 zur *Monatsschrift für Unfallheilkunde.*) Berlin, Julius Springer, 1935. 4.40 marks.

This work is an analysis of 109 fractures of the base of the skull. Of this series of cases 100 survived the injury, and it is largely this group which the author discusses. Attention is called to the various subjective and objective findings and also to the roentgenographic evidence of injury. These features are analyzed from the diagnostic and prognostic standpoints. Photographic and roentgenographic illustrations are helpful in supplementing the discussions. Numerous case reports are also included to emphasize the importance of different features.

The *Journal* wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Untersuchungen über Splenomegale Leberzirrhosen, sog. thrombophlebitische Milztumoren und chronisch Infektiöse Milzvergrösserungen. Unter besonderer Berücksichtigung der Pathogenese und der Behandlungsresultate bei Splenektomie. Rudolf Brandberg. *Acta Chirurgica Scandinavica*, LXXVII, Supplementum XL. Lund, 1935.

On the Disturbance of the Circulation in Spinal Anaesthesia. An Experimental Study. Oscar O. Schuberth. *Acta Chirurgica Scandinavica*, LXXVIII, Supplementum XLIII. Stockholm, P. A. Norstedt & Söner, 1936.

Contributions au diagnostic des pancréatites chirurgicales. Torsten M. Beckman. *Acta Chirurgica Scandinavica*, LXXVIII, Supplementum XLIV. Stockholm, Bokförlags Aktiebolaget Thule, 1936.

Anales; Revista mensual de Medicina, Cirugía y Especialidades (Valencia), III, Núm. 28, 1935.

Anales de Cirugía (Rosario), II, Nos. 1, 2, 1936.

*Behandlung der Verletzungen und Eiterungen an Fingern und Hand. 2 Aufl. M. zur Verth. Berlin, Julius Springer, 1936.

Corpos extranhos de esophago e bronchios extrahidos na Clinica Oto-Laryngo-Ophthalmologica da Assistencia Municipal do Rio de Janeiro, desde 1932. A. Caiado de Castro. *Boletim da Secretaria Geral de Saude e Assistencia*, No. 3, Supplemento. Rio de Janeiro, 1936.

Boletines de la Sociedad de Cirugía de Rosario, III, Nos. 1–3, 1936.

Bulletin of the National Tuberculosis Association, XXII, Nos. 7–9, 1936.

The Child (Washington, D. C.), I, Nos. 1, 2, 1936.

Cleveland Clinic Quarterly, III, No. 3, 1936.

Current Medicine (Los Angeles), III, Nos. 2, 6, 9, 1936.

*Disability Evaluation. Principles of Treatment of Compensable Injuries. Earl D. McBride, M.D., F.A.C.S. Philadelphia, J. B. Lippincott Company, 1936.

Estudio estadístico del Servicio de Urgencia del Hospital de San Juan de Dios, en los años de 1933 y 1934. Eduardo Perilla Alvarado. Republica de Colombia, Universidad Nacional, Facultad de Medicina. Bogotá, 1935.

The Forum of Osteopathy (Chicago), X, No. 5, 1936.

Hospital for Joint Diseases of the City of New York, Twenty-Ninth Annual Report, for the Year 1935. New York, 1936.

The Johns Hopkins University, School of Hygiene and Public Health, Announcements for 1936–1937. Baltimore, 1936.

Radiography and Clinical Photography (Rochester, N. Y.), XII, Nos. 1, 2, 1936.

Revue Médicale Française (Paris), XVII, No. 6, 1936.

The Rotarian (Chicago), XLVII, No. 5, 1935; XLVIII, No. 1, 1936; XLIX, No. 3, 1936.

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Chondromalacia Patellae. Axel Øwre. *Acta Chirurg. Scandinavica*, LXXVII, Supplementum XLI, 1936.

In order to study the pathological and clinical manifestations of chrondromalacia patellae, the knees of 124 subjects were examined at autopsy, and those of 400 persons were examined clinically. The appearance of oedema, of fibrillation, of fraying, and of erosion was tabulated in detail for various age groups. The changes usually began at the distal end of the medial facet of the patella and were noted in surprisingly young individu-

* To be reviewed in a later issue.

als. In older subjects, this location was often the site of the most pronounced degeneration.

In twenty-three cases in which the clinical findings were checked by post-mortem examinations, capsular tenderness at the medial side of the patella and pain on rubbing the patella against the medial femoral condyle were not present clinically without definite degenerative changes. Crepitation on passive movement was suggestive but not definite evidence of cartilage changes. Many of the cases of effusion of unrecognized etiology seemed to be caused by chondromalacia patellae. Transient locking with unusual movements was quite characteristic.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Ein kasuistischer Beitrag zur Beleuchtung der Melorheostose (Melorheostosis. A Case Report). H. Støren. *Acta Chirurg. Scandinavica*, LXXVIII, 94, 1936.

To the thirteen cases of melorheostosis recorded in the literature there is added another, that of a thirteen-year-old girl. Only the right lower extremity was involved. It was six centimeters shorter than the left and smaller, with knock-knee and valgus of the foot. Roentgenographic examination showed sclerotic areas in the lateral half of the distal femoral epiphysis, in both fibular epiphyses, and in the calcaneum, the cuboid, the cuneiforms, and the metatarsals. There was marked rarefaction of the surrounding bone. The right fibula was relatively shorter than the right tibia and thicker than the left fibula. Growth of the lateral half of the right distal femoral epiphysis was retarded.

There was an associated congenital displacement of the right fourth toe, so that it lay on the dorsum of the third, with plantar prominence of the third and fourth metatarsal heads. This deformity may support Zimmer's theory that melorheostosis is due to disturbances in the formation and development of a protosegment.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Über die Heilungsresultate der Unterschenkeldiaphysenfrakturen. Eine klinische Untersuchung an 389 Versicherungsfällen aus fünf grossen schwedischen Krankenhäusern. (The End Results in Diaphyseal Fractures of the Leg. A Clinical Investigation of 389 Insurance Cases from Five Large Swedish Hospitals.) Alf Lundgren. *Acta Chirurg. Scandinavica*, LXXVIII, Supplementum XLII, 1936.

In a monograph including the exhaustive study of 389 cases of fractures of the bones of the leg, taken from five of the largest hospitals in Sweden, the painstaking tabulation of all conceivable statistics was possible because the writer studied not only the insurance reports but the hospital case records as well. In 40 per cent. of the former, there were found to be inaccuracies of diagnosis. Removal from the statistics of all but fractures of the shaft increased the average period of total disability to seventeen months,—five and one-half for simple fractures and eleven and one-half for compound fractures. Other reports from the literature are quoted in which the inclusion of fractures of the ends of the bones considerably lowers these figures. The average age of thirty-eight years was higher than shown in most statistics.

The material furnished a means of comparing the methods of treatment. Half of the simple fractures were reduced and immobilized in plaster. Another fourth required no reduction. On the remainder, fifty-eight open reductions were performed, and extension was used in twenty-two cases. The compound fractures were treated by débridement and primary suture in most cases.

The anatomical position was of considerable significance in determining (1) the duration of temporary disability and (2) the percentage of cases showing permanent disability. The figures were as follows:

	Temporary Disability	Permanent Disability
Good anatomical position	130 days	4.0 per cent.
Moderately good anatomical position	200 days	28.3 per cent.
Poor anatomical position	339 days	76.9 per cent.

In addition to two cases among the amputations and five which were operated upon, there was only one case of permanent non-union.

The simple transverse fractures took longer to unite than did the oblique, while the comminuted fractures followed a less favorable course than either of these as to healing period and permanent disability. In the oblique fractures the final results after open reduction were somewhat better than following closed reduction. In compound fractures, however, the results were better from débridement, closure, and wire traction or plaster than from internal fixation. —*W. P. Blount, M.D., Milwaukee, Wisconsin.*

DIE SESAMBEINE DES I. METATARSOPHALANGEALGELENKS DES MENSCHEN. EINE RÖNTGENOLOGISCHE, KLINISCHE UND PATHOLOGISCH-HISTOLOGISCHE STUDIE. (The Sesamoid Bones of the Human First Metatarsophalangeal Joint. A Clinical, X-Ray, and Histopathological Study.) *Yngve Kewenter. Acta Orthop. Scandinavica.* Supplementum II, 1936.

More than 100 pages devoted exclusively to the sesamoid bones of the first metatarsophalangeal joint might seem too detailed. Dr. Kewenter has condensed and arranged the material so beautifully, however, that it is readily accessible and easily assimilated. He deals briefly with the rather inadequate literature covering this subject.

Dorsal plantar, axial, lateral, and occasionally plantar dorsal roentgenograms were taken in each of 800 cases. Additional studies were made of 465 children and of autopsy material. The results are clearly tabulated and illustrated by roentgenograms.

A chapter is devoted to a study of the ossification of these sesamoids. Another deals with the position, shape, size, and division of the sesamoids of the great-toe joint. The last chapter describes the pathological changes in the sesamoids with microscopic studies of autopsy material.

The average age of ossification of these sesamoids in boys is eleven years as opposed to nine in girls. Ossification may proceed from one or more centers. Multiple centers most frequently occur in the medial sesamoid. Once having begun, ossification proceeds rapidly to completion in one or two years. The medial sesamoid is larger and lies farther distal than the lateral in most cases.

Divided sesamoids occur much more frequently than is suggested in the earlier literature. In this series 33.5 per cent. of the patients had this condition. It is more frequent in the medial than in the lateral sesamoid.

There are lesions, but no characteristic ones, of the sesamoids of the first metatarsophalangeal joint. They may occur without the appearance of symptoms. In the collected material, fractures both of the undivided and of the divided sesamoids were observed. The changes of arthrosis deformans occurred in about 10 per cent. of the cases.—
W. P. Blount, M.D., Milwaukee, Wisconsin.

BIOLOGICAL BASIS OF SURGERY, PARTICULARLY ORTHOPEDIC SURGERY. George W. Hawley. *Am. J. Surg.*, XXXI, 438, March 1936.

This article, written on a subject little understood and by a surgeon of great experience, should be read in detail by every surgeon desiring a deeper insight into the relation of anatomy, physiology, and pathology to form, function, and tissue changes incident to disease and trauma.

"When surgical problems are approached from the basis of anatomy function or abnormal form and function, only one side of a polygonal problem is seen. Anatomy represents an existing standard of form, without appreciation of the processes producing it and those ceaselessly at work to effect change of form.

"The same applies to physiology and pathology; representing existing phenomena of normal and pathological functions.

"The combination of anatomy, physiology, pathology, including their offspring, physiological chemistry, bacteriology and their many first and second cousins; the careful weighing, assaying and grouping of all these is not enough to complete the picture. Their

composite grouping and fusion does not make human biology, biological factors, processes and laws as applied to the human organism.

"Biology is defined as, 'the science of life or living organisms,' but to make the definition inclusive would be to paint a picture of all living things, both vegetable and animal. For convenience biology may be divided into three divisions, plant, mammalian and human. Human biology might be defined as a combination of all those factors, processes and potential forces which are continuously working in the human organisms to regulate and determine both function and form in normal and abnormal states, from intrauterine birth through the period of growth, adult activity and decline.

"When an approach is made to a surgical problem the operator should have in mind the biological factors as well as the anatomical, the physiological and the pathological. In order to pattern surgical relief in accordance with the biological laws of purpose and design, he should make the following inquiries: (1) the biological processes which are at work, (2) what structures are involuting and which evoluting, (3) which are potentially weak and more frequently damaged and which are strong, (4) what attack is best suited to one in contrast to the other, (5) what is the relationship of form to function and the process which produced the form, (6) what are the processes of defense and repair, (7) what is the particular relationship of deformity to disability, (8) what are the processes affecting adjustment of function to deformity. Methods of surgical relief have been automatically guided and controlled to accord with biological laws, but not always do methods fit these laws. Success and failure have helped to show the way, for the history has been groping and stumbling in the dark to find the way. The man who first opened an abscess made a great discovery, but he was unaware of the full meaning. He discovered a biological process the importance of which did not become apparent until Lister exposed it to the light."—*Custis Lee Hall, M.D., Washington, D. C.*

ROTARY DISLOCATION OF ATLAS ON AXIS. J. O. Rankin. *Am. J. Surg.*, XXXII, 27, Apr. 1936.

The author adds nine new cases of this dislocation, which he believes is more frequent than is generally indicated. The mechanism is usually a mild force or twisting of the head with a resulting tear of the capsular ligament and dislocation of one of the atlantal facets. Symptoms are severe pain in one or in both sides of the neck and inability to rotate the head, with tilting of the head toward the dislocated side. Palpation reveals the spinous process of the axis on the opposite side of the midline toward the side to which the chin is rotated, and straightening the head increases the deviation of the axial spine from the midline. Satisfactory roentgenograms are often difficult to obtain, because of the position which pain causes the patient to assume. In eight of the cases reduction was by means of the jury-mast. Open reduction is difficult and rarely necessary. Casts were applied and retained for from five to eight weeks. In cases where manipulation is used the Walton method is preferred.—*Custis Lee Hall, M.D., Washington, D. C.*

TREATMENT OF SPRAINS BY INTERLIGAMENTARY INJECTION OF NOVOCAINE. René Leriche and G. Arnulf. *Am. J. Surg.*, XXXII, 45, Apr. 1936.

The authors advocate local injections of novocain into the ligaments of joints which are the seats of injuries or postoperative strains. They believe that a sprain is the reflex consequence of trauma, and specifically is the result of a distortion of the nervous apparatus present in the articular ligaments. The technique is injection of ten to twenty cubic centimeters, according to the importance of the articulation, of a 1-per-cent. solution of novocain into the region of the traumatized ligament at the spot of maximum tenderness. Care should be taken to inject the ligament itself. In the case of the hip, a long flexible needle is carried to the femoral neck and withdrawn about one centimeter, and the injection is then made. In this manner more rapid and complete restoration of function can be obtained. Best results are obtained in cases of simple sprain with articu-

lar impotency and the after-effects of sprain, such as pain and muscular atrophy, and in cases of operative sprain of ligaments following orthopaedic operations or manipulations.—
Custis Lee Hall, M.D., Washington, D. C.

FRACTURES OF THE SHAFT AND NECK OF THE FEMUR. REPORT OF 119 CASES. Irwin E. Siris and C. J. Delaney. *Am. J. Surg.*, XXXII, 277, May 1936.

During the past fifteen years, there have been ten cases of fracture of the neck of the femur in the Children's Surgical Service, Bellevue Hospital; six of these were reported by Colonna. Two cases were treated by the authors with Russell traction, and the other two by the Whitman method. Three cases of fracture of the shafts of both femora were treated by the Russell method with good results.

One hundred and nineteen children with fracture of the femur were treated in five years,—thirty, by a modification of Bryant's overhead suspension; fifteen, by reduction on the Hawley table, skin traction, and a plaster spica; and seventy-two, by the Russell method. Except in cases of children under four, where Bryant's method was used, the Russell method was used in all cases as a routine, with uniformly satisfactory results. The Thomas splint was used by the ambulance surgeons in all cases. There was no residual shortening in 109 of the 115 cases of fracture of the shaft of the femur. The authors use a modified apparatus which holds the leg in abduction and internal rotation.—
Custis Lee Hall, M.D., Washington, D. C.

CALCIFIED DEPOSITS IN SUBSCAPULARIS TENDON. C. E. Thompson and C. W. McLaughlin, Jr. *Am. J. Surg.*, XXXII, 524, June 1936.

The tendon of the supraspinatus muscle is much more frequently involved than are the tendons of the infraspinatus and teres minor muscles in cases of painful lesions of the shoulder. Causative factors are acute and chronic trauma to the shoulder and occupational strains, especially when the arm is used in the abducted position; also, focal infections and abnormalities of calcium metabolism are predisposing factors. Codman reported two cases of subscapular tendonitis in a group of 152 calcified lesions of tendons in painful shoulders. The authors suggest that in roentgenographic studies of the painful shoulder the lesion may be overlooked in the two usual views of the shoulder unless the lesser tuberosity is visualized. One case is reported in detail, in which treatment by open operation and removal of the involved calcified area gave a good result. Attention is called to the spontaneous disappearance of the deposit in many cases, with or without treatment. Economic factors enter into many cases, and operative procedure gives more prompt relief and a shorter period of disability.—*Custis Lee Hall, M.D., Washington, D. C.*

BCG VACCINATION IN WESTERN EUROPE. G. Gregory Kayne. *Am. Rev. Tuberc.*, XXXIV, 10, July 1936.

BCG is harmless. As an adjunct to other methods of prophylaxis, it produces a very partial immunity under certain conditions. Where the tuberculosis mortality is high, the economic conditions poor, and dispensaries and sanatoria inadequate, BCG clearly appears to offer a simple method of prevention. It is essential that the vaccine should be prepared *on the spot*, for the age of the culture has a direct bearing upon the attenuation and virulence. The indications for its use must depend upon the amount of tuberculosis and the extent of the antituberculosis organization in each country.—*Clarence A. Ryan, M.D., C.M., Vancouver, B. C., Canada.*

IL POTERE RIGENERATIVO DEI MENISCHI IN RAPPORTO ALLA TERAPIA (RICERCHE SPERIMENTALI). (The Regenerative Power of the Semilunar Cartilages in Relation to Therapy.) Giovanni Bazzocchi. *Ann. Italiani di Chir.*, XIV, 1237, 1935.

In carrying on this experimental work, the author removed the internal semilunar cartilages of rabbits. There was no postoperative immobilization. Perfect regeneration of the meniscus followed in all cases in which there was no infection.

The regenerated semilunar cartilage shows its highest structural differentiation after

approximately 100 days. At gross inspection and also microscopically, it is almost normal. The regeneration takes place from a fold of capsular tissue which extends between the two joint ends. Starting as simple fibrous tissue, it gradually undergoes structural changes with transformation to cartilage. The cartilage cells are at first very numerous, but gradually they get more scarce and become isolated. The collagenous fibers increase; elastic fibers appear late. Vessels are seen at first, but they gradually disappear with more mature structural differentiation of the meniscus. In man, regeneration of the semilunar cartilage is never as advanced as in animals. It remains more fibrous than cartilaginous. In lesions of the semilunar cartilages early and complete removal of the injured meniscus is the treatment of choice. Incomplete removal involves the danger of degenerative arthritic changes of the joint ends. Even after a lapse of five months following the removal of the semilunar cartilages, animals do not show arthritic changes.—*Ernst Freund, M.D., Venice, Florida.*

TUBERCULOUS DISEASE OF BONE. M. M. Cruickshank. *The Antiseptic*, XXXIII, 129, March 1936.

The author discusses the forms and treatment of bone tuberculosis in cases observed on his Service at the Medical College in Madras. He outlines the clinical course of tuberculosis in the long bones; in the short bones, such as the phalanges; in the vertebrae; and in less frequent sites, such as the clavicle, the sternum, the ribs, and the flat bones of the skull. He recognizes three clinical pathological varieties,—the localized forms, the spreading forms, and the atrophic form. He points out that there may also be a fourth, the hypertrophic form, which, however, is likely to be complicated with syphilis, especially in the Oriental races.—*Robert M. Green, M.D., Boston, Massachusetts.*

ERYTHROCYTE SEDIMENTATION RATE IN RHEUMATOID ARTHRITIS AND ALLIED CONDITIONS. Govind Lal Sharma. *The Antiseptic*, XXXIII, 355, June 1936.

From the Department of Pathology in the University of Lucknow, the writer presents the results of his laboratory studies in the erythrocyte sedimentation rate in rheumatoid arthritis and in allied conditions. After observing this rate in a series of pathological conditions compared with a group of normal controls, the author concludes that, although the sedimentation rate is a non-specific reaction, it is definitely prolonged in atrophic infective rheumatoid arthritis and in hypertrophic degenerative osteo-arthritis, and can, therefore, render definite diagnostic service in the recognition of these two important varieties of chronic joint disease.—*Robert M. Green, M.D., Boston, Massachusetts.*

L'ARTROTENODESI TIBIO-PERONEO-ASTRAGALICA NEI POSTUMI DELLA PARALISI INFANTILE (Arthrotenodesis of the Ankle Joint Following Infantile Paralysis). Carlo Re. *Arch. di. Ortop.*, LI, 675, 1935.

The author reports 150 cases of poliomyelitis in which arthrodesis of the ankle joint was performed, together with tenodesis of the foot extensors. He emphasizes the necessity of observing carefully the indication for this operation. It is worthless in the case of an entirely flat foot or in that of a foot with markedly reduced muscle power. It aims at correction of foot deformity and at stabilization. In short-equinus deformity or in cases with some varus of the heel, the operation permits better correction than does subastragaloid arthrodesis.—*Ernst Freund, M.D., Venice, Florida.*

ARTRODESI E TRAPIANTO CONTEMPORANEO NELLA PARALISI DELLA SPALLA (Arthrodesis and Muscle Transplantation in Paralysis of the Shoulder). Andrea Albanese. *Arch. di Ortop.*, LI, 763, 1935.

In cases of paralysis of the shoulder, Albanese has worked out a method by which one may obtain at the same time good intra-articular arthrodesis, solid extra-articular bony union, and transplantation of the upper portion of the trapezius to the upper end of the humerus. Through a posterior incision, the lateral half of the spina scapulae is removed, together with the insertion of the trapezius. The joint is opened and all of the

cartilage is removed. A small groove is chiseled in the upper end of the humerus behind the greater tuberosity. The spina scapulae is rotated for about 190 degrees and firmly pushed into the groove in the humerus. This rotation tightens the fibers of the trapezius muscle. The wound is closed, and the arm is immobilized in 80 degrees of abduction and 25 to 30 degrees of forward flexion. After three months of immobilization, functional reeducation is possible in a special brace which permits rotation of the scapula.—*Ernst Freund, M.D., Venice, Florida.*

ESPERIENZE SULL'IMPIEGO DI MATERIALE DI SUTURA IMPERMEABILIZZATI NELLA CHIRURGIA DELLE OSSA (Experiences in Bone Surgery with Suture Material Rendered Impermeable). Andrea Albanese and Felice Parravicini. *Arch. di Ortop.*, LII, 5, March 1936.

A short historical review on osteosynthesis is followed by the report of numerous experiments with different absorbable materials which had been rendered impermeable,—silk impregnated with rubber, chromic catgut, and linen prepared with cellulose. Such material remains preserved for a very long time, even when passed through the bone. Roentgenographic follow-up showed the material up to nine months after application. Specimens taken after this period and investigated anatomically still exhibited a good mechanical resistance,—silk impregnated with rubber showed the least deterioration, while chromic catgut had almost entirely disappeared. Impregnated silk gave the least tissue reaction, and the use of chromic catgut led to irregular periosteal reaction.—*Ernst Freund, M.D., Venice, Florida.*

SU UN CASO DI EMANGIOMA MUSCALARE PRIMITIVO DELLA GAMBA (A Case of Primary Hemangioma in the Muscles of the Leg). Luigi Imperati. *Arch. di Ortop.*, LII, 79, March 1936.

The author discusses in a general way hemangioma in the muscles of the lower extremity and gives a review of the cases reported in the literature. Careful analysis reveals that not all of the cases reported can be classified as primary hemangiomata. A case of cavernous hemangioma in the gastrocnemius muscle is reported, including the pathological study. The treatment of choice is surgical removal. If the tumor is too extensive, amputation may be indicated.—*Ernst Freund, M.D., Venice, Florida.*

GINOCCHIO RECURVATO ANCHILOTICO CONSECUTIVO AD ARTRITE PIOGENA POST-TRAUMATICA (Genu Recurvatum with Ankylosis Following Pyogenic Post-Traumatic Arthritis). Antonio Poli. *Arch. di Ortop.*, LII, 167, March 1936.

The author reports a case of severe genu recurvatum with bony ankylosis of eleven years' duration in a seventeen-year-old boy. A wedge resection was performed with excellent results. The analysis of the different factors contributing to the deformity reveals (1) weight-bearing and the action of the quadriceps muscle, and (2) uneven growth due to partial destruction of the epiphyseal plate.—*Ernst Freund, M.D., Venice, Florida.*

RÔLE OF THE RETICULO-ENDOTHELIAL SYSTEM IN THE DEPOSITION OF COLLOIDAL AND PARTICULATE MATTER IN ARTICULAR CAVITIES. John G. Kuhns and Harold L. Weatherford. *Arch. Surg.*, XXXIII, 68, July 1936.

In a logical series of experiments, the authors studied the deposition in joints of colloidal and particulate matter that had been introduced into the body through the gastro-intestinal tract and by subcutaneous injection. They assumed that this foreign matter was carried through the blood stream and they showed that it was stored in the joints, chiefly in the elements of the reticulo-endothelial system. Using rats as their experimental animals, they determined the amount of deposition of this particulate matter in the normal joint and then compared this with the findings in the joints that had been altered by direct injury, by irritative injection, or by the enforced rest induced by

through the body of the fifth lumbar vertebra into the anterior aspect of the first sacral segment for a distance of two inches. A bone graft from the tibia was driven into this hole so that it fitted tightly.

A year later the patient's deformity was largely corrected. He could walk without difficulty or pain.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

THE SIGNIFICANCE OF LUMBOSACRAL TRANSITIONAL VERTEBRAE. G. A. G. Mitchell. *British J. Surg.*, XXIV, 147, July 1936.

This article contains a careful study of the anatomical variations in the lumbar spine and sacrum in the higher primates, with the changes resulting from man's assuming the erect position. Sacralization of the fifth lumbar vertebra or lumbarization of the first sacral vertebra may produce painful symptoms. These are produced (1) by impingement of the transverse process on the sacrum or lateral bending, (2) in unilateral cases, by this impingement acting as a fulcrum for the spinal column, which then acts as a lever to separate the vertebra from the sacrum and to tear ligaments, (3) by the formation of a bursa, (4) by peri-arthritic changes, and (5) by stretching of the fourth lumbar nerve.

Conservative treatment is advised, but operation must be considered if the patient is not relieved.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

THREE CASES OF FRACTURE RESULTING FROM ELECTRIC SHOCK. H. Jackson Burrows. *British J. Surg.*, XXIV, 159, July 1936.

Three instances of fracture of the upper end of the humerus, occurring as a result of a non-fatal electric shock, are cited.

The first patient was a barber who received a shock while handling a vibro-massage machine. The next day he complained of severe pain in his shoulder. Nine weeks later a roentgenogram showed a crush fracture of the head of the humerus.

In the second case, the injury was from a shock by an electric kettle, followed by a fall. It was not certain whether or not the fall contributed to the avulsion and fracture of the greater tuberosity of the humerus, which roentgenographic examination revealed.

In the third instance, the patient fell against a water tank while carrying an electric lamp. Roentgenograms showed an impression fracture of the humeral head opposite the glenoid.

It is suggested that the fractures were caused by the violent, uncontrolled contraction of the shoulder muscles. The question is raised whether the passage of the current through the bones was a factor.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

OSTEOCHONDRITIS DEFORMANS COXAE JUVENILIS OR PERTHES' DISEASE: THE RESULTS OF TREATMENT BY TRACTION IN RECUMBENCY. Arthur L. Eyre-Brook. *British J. Surg.*, XXIV, 166, July 1936.

The various theories in regard to the etiology of Perthes' disease are discussed. There are five early signs: (1) increased density of the epiphysis, (2) increased depth and clarity of the joint space, (3) early flattening of the epiphysis, (4) early metaphyseal cavitation, and (5) Courtney Gage's sign. The late signs are: (1) flattening and further condensation of the epiphysis, (2) broadening of the neck of the femur, (3) confluent cavitation of the metaphysis, (4) partial collapse of the "cavited" metaphysis, (5) regeneration of the more or less deformed epiphysis, (6) condensation of the regenerated epiphysis, (7) sometimes partial disappearance of the epiphyseal line in its outer portion, (8) the appearance of the transverse cervical line, and (9) adaptive acetabular changes.

The author believes that traction in recumbency is the ideal treatment for children under seven years of age, or for patients over this age if in an early stage of the disease. Sliding traction with weight and pulley or Pugh's extension are the methods used. The end results are shown by excellent roentgenographic reproductions. The results obtained are believed to be permanent.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

Adhesions of Joints and Injury. R. Watson Jones. *British Med. J.*, I, 925, May 9, 1936.

The author states that the conditions under which adhesions form around joints constitute one of the fundamental problems of fracture treatment. It is a problem which is frequently misunderstood.

Joint stiffness after injury is due to adhesion of the capsular plications, which, in turn, is the result of organization of any exudate in the periarticular tissues. In fact, it is the recurrence and persistence of serofibrinous exudation which provides the key to the problem of adhesion formation. Frequently the source of the exudate is extra-articular, as the joint itself is normal.

The following factors, several of which may occur in the same case, are considered responsible for continued or recurrent exudation: (1) disuse with continued venous stasis, (2) recurrent oedema, (3) the recurrent trauma of daily passive stretching or repeated manipulation, (4) the constant trauma of immobilization in a position of strain, (5) continued infection near a joint, and (6) the continued irritation of foreign bodies near a joint.

Immobilization in itself is not a major factor in the development of adhesions when uncomplicated by other factors. Any adhesions formed are the result of venous stasis. Once a patient resumes active use of the part, recovery of normal function occurs.

The author emphasizes the serious disability that follows the presence of continued oedema in a limb which is immobilized. "There is no more potent factor in adhesion formation, for oedema is the glue of which adhesions are made." Swelling is controlled by external pressure and active muscle exercise.

The author particularly denounces passive stretching and exercise, since such therapy results in a continual recurrent traumatic exudation, with the formation of fresh adhesions.

Under the heading "Foreign Bodies Near Joints," the use of skeletal traction near joints is condemned particularly, because where the foreign body (pin or wire) penetrates the skin there is the possibility of a low-grade infection. This infection may be of minimal degree and may show no external signs, but it is the cause of continued exudation in neighboring tissues, and hence of adhesions which are much more resistant than the adhesions of simple immobility. Again, in contrast to fracture experience in this country, the author states that the factors noted account for the frequency of permanent stiffness of joints when articular fractures are treated with wires and screws. For example, he believes that olecranon fractures treated by internal wire fixation usually exhibit permanent limitation of extension movement, because the wire is associated with a low-grade inflammatory reaction, and the resultant irritative serofibrinous exudation gives rise to periarticular adhesions which are particularly resistant.—*G. E. Haggart, M.D., Boston, Massachusetts.*

Treatment of Tuberculosis of the Spinal Column. M. Grobelski. *Chir. Narz. Ruchu*, IX, 5, 1936.

The author did not notice any distinct results after the use of Friedmann's serum. Calvé's method of treatment of abscesses by paracentesis with special trocars gave negative results. In eighty cases Albee's operation was performed. In 48 per cent. the results were good; in 15 per cent., moderate; and in 15 per cent., unsatisfactory; 22 per cent. of the patients died. The author believes that one should not operate on children before the twelfth or fifteenth year. Albee's graft may be considered as an internal corset which abbreviates the duration of convalescence and stabilizes the results obtained by the preceding conservative treatment.—*Joseph K. Narat, M.D., Chicago, Illinois.*

Osteoplastic Operation on Acetabulum as Treatment of Congenital Dislocation of Hip. Z. Ambros. *Chir. Narz. Ruchu*, IX, 89, 1936.

This method was used in twenty-eight cases. Perfect results were obtained in 18.2 per cent.; good results, in 45.5 per cent.; relatively good, in 18.1 per cent.; and bad results

in 13.6 per cent.; in 4.6 per cent., no check-up was possible.—*Joseph K. Narat, M.D., Chicago, Illinois.*

RESECTION OF THE CLAVICLE FOLLOWED BY ITS REGENERATION. F. Borusiewicz. *Chir. Narz. Ruchu*, IX, 177, 1936.

In the course of a general septicaemia, osteomyelitis of a clavicle developed in a man twenty-one years of age. A subperiosteal resection was followed by rapid recovery. Complete regeneration took place, and the function of the corresponding upper extremity became normal. *Joseph K. Narat, M.D., Chicago, Illinois.*

FRACTURA DE LA COLUMNA VERTEBRAL. J. I. Mitchell. *Cir. Ortop. y Traumatol.*, III, 207, 1935.

Among fractures of the spine those of the cervical region are most frequently complicated by paralysis. A spinal puncture is indicated in such cases. If the flow of the spinal fluid is blocked by an osseous obstruction, an immediate laminectomy is advisable. If no paralysis is present, or if it has been eliminated by an operation, a hyperextension of the vertebral column is indicated. This can be accomplished by applying Wallace's or Davis' method, or by using Herzmark's adjustable convex frame. Rogers' frame, which is a modification of Bradford's frame, may also be employed. In selected cases the methods described by Dunlop, O'Donohue, or Jones may be considered. The prognosis of fracture of the spine is not as bad as is frequently assumed.—*Joseph K. Narat, M.D., Chicago, Illinois.*

NICOLA'S OPERATION IN RECURRENT DISLOCATIONS OF THE SHOULDER. A. Inclán. *Cir. Ortop. y Traumatol.*, III, 231, 1935.

On revising his own statistics, the author finds that among 4,500 patients 113 were treated for dislocations, twenty-eight of which affected the shoulder. Of these dislocations, eleven were of the recurrent type. Although he recommended surgical intervention to all of these patients, only five followed his advice, and the present paper refers to them. In one case the author employed a modification of his own, by working out a tunnel in the posterior plane of the head of the humerus, to prevent its posterior displacement. He recommends this modification only in case of posterior dislocation. A woman operated on according to this method had an epileptic attack one week after discharge from the hospital. Contrary to previous attacks, this one did not produce a dislocation of the affected shoulder, but the other shoulder became dislocated, proving the severity of the attacks and the success of the operation. The author asserts that, in his opinion, Nicola's method ought to be the procedure of choice. Although he considers that the time which has elapsed since the surgical intervention is too short for claiming conclusive results, he stresses the fact that to date he has not observed any recurrences.—*Joseph K. Narat, M.D., Chicago, Illinois.*

IMPROVED TECHNIQUE OF IMMOBILIZATION WITH THE SMITH-PETERSEN NAIL FOR OSTEOSYNTHESIS OF FRACTURES OF THE FEMORAL NECK. A. Inclán. *Cir. Ortop. y Traumatol.*, IV, 5, 1936.

The author has devised an apparatus which facilitates immobilization with the Smith-Petersen nail in fractures of the femoral neck. This instrument consists of two small hollow rods, through which the Kirschner wires are pushed like the lead of an automatic pencil, and of a transverse piece with three slots,—one in the center for the Smith-Petersen nail, and one on each side to introduce the two rods. After reduction of the fracture according to Leadbetter's method, the limb is kept in abduction of from 30 to 35 degrees and in internal rotation. A vertical incision, three inches long, reaches the lower end of the trochanter. The infratrochanteric fossa is exposed and the center of Poupart's ligament is marked. The anterior fixing rod is introduced along the anterior aspect of the femoral neck in the direction of Poupart's ligament, until it touches the bone. The wire is then inserted. In the same manner the other rod is introduced along the posterior

border of the femoral neck. The external ends of the two rods are slipped through the corresponding slots in the transverse bar, which is pushed to the bottom of the wound until it almost touches the bone. The direction of the bar is from the center of Poupart's ligament to the infratrochanteric fossa. A Smith-Petersen nail is then introduced; a dressing is applied; and a roentgenogram is taken. If the direction of the guiding apparatus and of the nail is correct, the nail is driven into the cephalic fragment, whereupon the parts of the guiding instrument are removed. If the angle of inclination requires some modification, the nail is withdrawn from the cortex and the position is corrected. The wound is closed in the usual manner and the extremity is immobilized in a plaster spica.—*Joseph K. Narat, M.D., Chicago, Illinois.*

SURGICAL TREATMENT OF TWO CASES WITH OBSTETRICAL PARALYSIS OF UPPER EXTREMITIES. S. Toledo and J. P. Lorio. *Cir. Ortop. y Traumatol.*, IV, 31, 1936.

The authors present two cases with deformities of the upper extremity produced by obstetrical paralysis. One of them was diagnosed as belonging to the so called mixed or Duchenne-Erb-Klumpke type, while the other was of the superior radicular type. In both cases the arm was kept in a position of abduction and marked internal rotation. The corresponding hand was not able to reach the mouth. One case could be attributed to the use of forceps; no such clue, however, could be found in the other case. Conservative treatment was unsuccessful. The surgical treatment consisted of an osteotomy above the insertion of the deltoid muscle, according to the method suggested by Nové-Josserand. The cosmetic and functional results were satisfactory.—*Joseph K. Narat, M.D., Chicago, Illinois.*

CASE OF MALUNION OF COLLES' FRACTURE AND ITS ORTHOPAEDIC REPAIR. A. B. Inclán. *Cir. Ortop. y Traumatol.*, IV, 63, 1936.

Surgical intervention in cases of Colles' fracture with malunion should aim at the anatomical reconstruction of the articular line of the radius, especially of the bistyloid line, and at the correction of the deformity. The author recommends an osteotomy of the radius at the height of the fracture with restoration of the epiphysis to its correct position and introduction of an osseous wedge at the site of the fracture, in order to lower the styloid process of the radius without using osteosynthetic material. A preliminary ulnar osteotomy is not necessary in adolescents and children on account of favorable anatomical conditions at this age. In adults such a preliminary procedure is unavoidable as it facilitates a proper setting of the radius; otherwise the interposition of the interosseous ligament and the pronator quadratus muscle interferes with reduction of the fragments. An osteotomy of the ulna with removal of a wedge involves the danger of nonunion, as observed in the author's case. Pain, stiffness of the articulation, and weakness after exertion disappeared entirely after the surgical procedure.—*Joseph K. Narat, M.D., Chicago, Illinois.*

OBSERVATIONS ON ETIOLOGICAL FACTORS IN RHEUMATOID ARTHRITIS. Govind Lal Sharma. *J. Indian Med. Assn.*, V, 535, June 1936.

The author presents a brief study of the etiological factors involved in rheumatoid arthritis. It is his conclusion that the arthritides of constitutional nature, dependent on non-specific, focal infections, are more numerous and even more important than those associated with specific infective agents like the gonococcus or the streptococcus. In his work at Lucknow, he has found this type of arthritis particularly amenable to cure by eradication of focal sepsis and by the employment of vaccine therapy.—*Robert M. Green, M.D., Boston, Massachusetts.*

CONGENITAL DISLOCATION OF THE HIP. H. A. T. Fairbank. *Med. Press and Circ.*, CXCII, 7, January 1, 1936.

The author points out several physical signs which help in making a diagnosis of "congenital hip" in infants. Some of these are: apparent inequality of leg length,

asymmetry of gluteal creases or of adductor creases, apparent female type of pelvis, and palpation of the femoral head beneath the femoral artery.

The more common findings, such as the later appearance of the Trendelenburg sign, etc., after walking is begun, are discussed. The x-ray appearances, from the early subluxating stage to the development in old cases of a secondary acetabulum on the wall of the ilium, are also considered.

The treatment advocated by the author is the "bloodless reduction method" until the child is so old that an attempt proves unsuccessful. After this, open reduction is indicated. *Herbert E. Hipps, M.D., Marlin, Texas.*

THE PHYSIOLOGICAL BASIS FOR THE MODERN TREATMENT OF FRACTURES. A. L. d'Abreu. *Med. Press and Circ.*, CXCII, 299, April 1, 1936.

During the last few years there has been a decline in the number of patients with fractures who have been referred to the massage departments; coincidental with this, there has been a marked decrease in the periods of incapacity, with a saving of compensation fees and lost wages.

The healing process of two adjacent fractured bone ends is described and the author explains why excessive motion between these healing fragments prevents union.

The author cites Watson Jones's article on "Non-Union" in substantiation of his own observations and presents further instances in proof of this, all of which is to point out the non-physiological aspects of early passive motions and massage in fracture treatment.

The modern tenets of fracture treatment are:

1. Accurate anatomical reduction;
2. Complete immobilization until sound union has occurred;
3. As full functional activity of the limb as is possible. The further merits of the modern treatment of fractures are discussed, including the psychological effect on the patient, which, in the newer methods, is uniformly good.—*Herbert E. Hipps, M.D., Marlin, Texas.*

ASSOCIATION OF B. COLI INFECTION AND RHEUMATOID ARTHRITIS. Gerald Slot and P. M. Deville. *Med. Press and Circ.*, CXCIII, 4, July 1, 1936.

The obscure etiological factors in rheumatoid arthritis are pointed out. Nine out of twenty-four patients with rheumatoid arthritis were found by the author to have an unsuspected bacilluria. Thinking that this might be a factor of importance in the origin or progress of the disease, these patients were given alkaline medication, with resultant subjective improvement.—*Herbert E. Hipps, M.D., Marlin, Texas.*

GONOCOCCAL ARTHRITIS. John T. Armstrong. *Med. Press and Circ.*, CXCIII, 9, July 1, 1936.

Gonococcal arthritis in a patient having gonorrhoea is often brought on by neglect of proper care, by exposure to cold, by bodily stress, by excessive drink, and by other excesses.

The first essential in treatment is to place the joint at rest and to keep it at rest in such a position that it will be the most useful if stiffness should occur. For example, the knee should be straight; the elbow, flexed with the thumb up; the wrist, in dorsiflexion; the spine, in extension, etc.

When acute symptoms have subsided, active and passive motion is indicated if carefully and gently carried out.

The use of typhoid bacterial injections and different drugs is discussed and their respective merits are evaluated.

Foci of infection in the prostate or the vesicles should be treated by massage, topical applications, and diathermy or by a Belfield operation.—*Herbert E. Hipps, M.D., Marlin, Texas.*

Die Behandlung der Pseudarthrose des Kahnbeines der Hand (Treatment of *Pseudarthrosis of the Scaphoid Bone of the Hand*). *Hans-Heinrich Westermann. Monatschr. f. Unfallheilk.*, XLIII, 287, June 1936.

For ununited fractures of the carpal scaphoid Westermann recommends a drilling operation rather than the extirpation of the smaller fragment. The operation is performed under local anaesthesia, with a small incision in the anatomical snuff-box. A drill is introduced into the fragments which are visualized by means of the x-ray. After the drill holes have been made, the wound is closed and immobilization in plaster-of-Paris is resorted to for a period of six weeks.—*I. William Nachlas, M.D., Baltimore, Maryland.*

Les rhumatismes de la chimiothérapie (Chemotherapeutic Rheumatism). A. Tzanck, F. Layani, E. Sidi, and H. P. Klotz, *Presse Méd.*, XLIV, 1052, 1936.

The cutaneous, hepatic, and renal accidents of chemotherapy have been studied in detail, but the articular manifestations appear to have been neglected. Study of the literature and of 215 of the authors' own cases led to the conclusion that there is a definite arthropathy associated with chemotherapy. Clinically, the condition is found three times as frequently in women as in men, and it usually attacks young persons between the ages of twenty and forty. The symptoms appear suddenly and at any time in the course of the treatment. The amount of the drug does not appear to influence the onset of symptoms. Most commonly, the affection presents itself as a polyarthralgia, but it may appear as a hydro-arthrosis. More rarely it may accurately simulate acute rheumatic fever, with its polyarticular involvement, sweating, gastro-intestinal upset, etc. Since the Aschoff body is no longer considered as pathognomonic of acute rheumatic fever, the differentiation between the two conditions can be made only on the ground that the *patient with a chemical arthropathy never suffers involvement of the cardiac structures.*

The arsenical form of arthropathy is usually of the polyarthralgic type and is frequently associated with nitritoid crises. The bismuth form is usually of the non-articular type, develops late, and is associated with stomatitis, etc. Gold, aristol, atophan, bromides, quinine, novocain, the barbiturates, and other chemicals have been reported as giving rise to joint symptoms. The barbituric form, it is to be noted, develops late and tends toward ankylosis and amyotrophy, but may be completely obviated by discontinuance of the drug.

The general characteristics of the group cannot be explained on the basis of infection or toxic reaction. It is the author's opinion that only a disturbance of the sympathetic vasomotor system can adequately explain the diverse manifestations of the chemotherapeutic arthropathies. That form of arthropathy which has been observed to develop *ten days after the beginning of medication presents the typical picture of an anaphylactic* reaction with the associated skin rashes, etc. In this sense the chemotherapeutic rheumatisms resemble the protein rheumatisms of serum disease, described by Bezançon, Weil, and others. Carrying the argument further, the authors quote Bezançon to the effect that the pseudo-infectious arthropathies observed in scarlet fever, dysentery, and gonococcal infections may be related to the protein and chemical arthropathies. In similar manner, the authors raise the *question of the relation of acute rheumatic fever to* these previously mentioned arthropathies. They express the opinion that acute rheumatic fever is an infectious disease, due to an unknown specific virus which, however, determines articular reactions resembling those of the protein or chemical types. The consequence of this is that all rheumatisms are differentiated from that type of arthropathy in which the causative organism can be recovered.

This article is extremely interesting and stimulating. It is well worth careful rereading in the original.—*Henry Milch, M.D., New York, N. Y.*

Double Vertical Fracture of Pelvis. Case Report. L. Ramallal. *Rev. Méd.-Soc.*, VI, 169, 1935.

A twenty-eight-year-old miner sustained a double vertical fracture of the pelvis. The posterior fracture line passed through the right side of the sacrum and the anterior

fracture line went through both branches of the left pubic bone; the lower branch was fractured in two places. A shortening of two and five-tenths centimeters resulted. This was responsible for a compensatory lumbar lordosis.—*Joseph K. Narat, M.D., Chicago, Illinois.*

UN CASO DE "PATELLA CUBITI" DOBLE. A. Oller and J. Ruiz Gijón. *Rev. Méd.-Soc.*, VIII, 576, 1935.

In the case reported, large sesamoid bones were present bilaterally in the distal insertion of the triceps muscles of both arms. They resembled the patellae. Such formation may be mistaken for a fracture of the olecranon.—*Joseph K. Narat, M.D., Chicago, Illinois.*

SHEPHERD'S FRACTURE. J. M. S. Bordona. *Rev. Méd.-Soc.*, V, 20, 1936.

The posterior apophyses of the astragalus can be visualized in roentgenograms taken in the lateral direction. There are two such apophyses: internal and external. The first, if separated from the remaining bone, can be mistaken for a tubercle found on the posterior aspect of the astragalus at the point of the insertion of the posterior fibers of the deltoid ligament of the astragalotibial articulation. The external apophysis, which may have a triangular, square, or rectangular shape, is located between the insertions of the posterior astragaloperineal and posterior astragalocalcaneal ligaments. Under normal circumstances, the astragalus forms from one ossification center. Occasionally the embryonic cartilage forms two such centers, from which the astragalus proper and the so called os trigonum develop. A fracture of the postero-external apophysis can easily be mistaken for os trigonum or Shepherd's fracture. Such a fracture may be the result of a violent torsion of the foot or of a direct trauma with the foot in a position of plantar hyperflexion. Hypertrophy of the posterior apophysis is a predisposing factor. In the absence of complicating lesions the prognosis is good. Immobilization for from fifteen to twenty days is necessary.—*Joseph K. Narat, M.D., Chicago, Illinois.*

BEITRAG ZUR OSTEOCHONDRITIS DISSECANS DES HUFTKOPFES (Osteochondritis Dissecans of the Head of the Femur). E. Friedl. *Röntgenpraxis*, VIII, 16, 1936.

Aseptic necrosis of the head of the femur may occur in two different clinical and roentgenographic types: when the necrosis is wide-spread, collapse of the whole bone takes place, with the resultant picture of Perthes' disease; if the necrosis is limited to a small subchondral portion of the head, a piece of necrotic bone sequestrates and osteochondritis dissecans develops. This disease in the hip joint was first described by Haenisch in 1925. Since that time few papers on this subject have been published, but all authors agree on the rare occurrence of the disease. Friedl, however, describes not less than twenty-one cases of osteochondritis dissecans in the hip joint and has found this localization as common as in the knee joint. The free body develops as a rule at the upper pole of the head, the place of greatest weight-bearing; only one case showed the joint mouse coming from the medial lower plane of the head. It is usually oval in shape, from one to three centimeters long and from one-half to one centimeter thick. It is not freely movable and is fixed at the surface by fibrous tissue. Immigration from the bed has not been observed. The further development is either reattachment of the mouse in the defect or complete resorption. This development is chronic and finally the picture of arthrosis deformans appears. The origin is either spontaneous or a secondary injury after hypothyreotic derangement of the growth of the head of the femur, or following reposition of a congenital or traumatic dislocation of the hip joint, slipped epiphysis, or healed fracture of the neck of the femur. Osteochondritis dissecans of the knee, elbow, and hip joints, occasionally combined with Perthes' or Köhler's disease, has been described in the same family.

The preliminary stage is marked by the development of necrosis until the time of demarcation, and is mostly free of clinical and roentgenographic symptoms. The second stage, demarcation of the mouse, occurs with pain on walking and long standing, and with

limitation of motion. In exceptional cases, patients are symptom-free during this stage, as noted by the author in a bilateral case in a man, thirty-five years old, in whom no changes developed during a four-year period of observation.—*Joseph Wolf, M.D., Iowa City, Iowa.*

OSTEOCHONDRITIS DISSECANS AS RELATED TO TRAUMA. Robert V. Funsten and Prentice Kinser. *Southern Med. J.*, XXIX, 262, March 1936.

The authors report a typical case of this disease in the carpal scaphoid, as well as a case in which the lesion was on the palmar surface of the semilunar cartilage. Their series consisted of twenty-three cases and of these only nine were of the classical type. Trauma has generally been accepted as the logical cause of this condition.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

BONE SYPHILIS. J. S. Speed and H. B. Boyd. *Southern Med. J.*, XXIX, 371, Apr. 1936.

Lesions may appear in the primary, secondary, or tertiary stages of the disease. Lesions were found in one-half of one per cent. of the patients admitted to the Campbell Clinic in Memphis. Age incidence, location, pathology, and roentgenographic changes are described. Diagnosis is difficult, and resort to antiluetic treatment is often necessary to distinguish this disease from other conditions The results of serological tests are variable, especially in adults.

The influence of trauma on bone syphilis is discussed. The authors feel that the influence of syphilis on the healing of fractures has been exaggerated. Most fractures in syphilitics will heal properly if handled correctly.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

RECOGNITION OF THE MODERN TREATMENT OF BROKEN HIPS. Lawson Thornton and Calvin Sandison. *Southern Med. J.*, XXIX, 456, May 1936.

The authors consider fixation of the fractured neck of the femur by a Smith-Petersen nail as the modern treatment. No consideration is given to any other method. For the past two years they have used no other method. All ages and all conditions have been treated by "blind nailing" controlled by roentgenograms in two planes. Uniform success has resulted in their series of thirty-two cases. A description of their technique and method of taking roentgenograms is included.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

REPAIR OF THE LIGAMENTS OF THE KNEE. REPORT OF A NEW OPERATION FOR REPAIR OF THE ANTERIOR CRUCIAL LIGAMENT. Willis C. Campbell. *Surg. Gynec. Obstet.*, LXII, 964, June 1936.

The writer discusses the indications for repair of the knee ligaments and describes the anatomy and mechanism of these ligaments. The most frequent and disabling injuries are those of the internal lateral ligament, the internal semilunar cartilage, and the anterior crucial ligament, either alone or in combination. In the writer's series there was *no instance of injury of the external lateral ligament or of the posterior crucial ligament* disabling enough to warrant operative measures.

An operative technique for replacement of the anterior crucial ligament is described and clearly illustrated. In brief, it consists of obtaining a strong piece of tendon, fascia, and capsule, one-third of an inch wide by eight inches long, through an incision just mesial to the patella; this is left attached at its distal end, and is then threaded through drill holes in the tibia and femur placed as nearly as possible in the line of the original anterior crucial ligament. The strip is sutured above and lateral to the periosteum and fascia lata, with the knee in 140 degrees of flexion. A posterior splint is applied, with the limb in full extension, and is worn for three weeks; then active and passive motion is started. The incision permits arthrotomy if necessary. Apparently excellent results have been obtained in nine cases.

The advantages of this procedure are "the extreme simplicity, minimum trauma, shorter incisions, and decrease in operating time".—*Richard [illegible], M.D., Santa Barbara, California.*

ÜBER DIE KNOCHENSTRUKTUR BEI MARMORKNOCHENKRANKHEIT (Bone Structure in Marble Bone). Walter Laubmann. *Virchows Arch. f. path. Anat.*, CCXCVI, 23, 1935.

This is a minute description of the histological findings in Albers-Schönberg disease. The appearance is that of maldevelopment derangement of enchondral ossification, and slow apposition of the primary osteoid cells without preceding resorption of the cartilage. A thickened compacta with small osteoblasts is formed only in the diaphyseal region. The spongiosa is dense and forms an "inner compacta". The findings in the epiphyses and in the metaphyses harmonize with those in the short tubular bones. In the diaphysis there is, aside from the formation of primary osteoblasts, a metaplastic chondroid-osteoid development. The bone marrow shows mostly a fibrous degeneration; therefore, anaemia and myeloid metaplasia of the liver, the spleen, and the lymph glands follow.—*Joseph Wolf, M.D., Iowa City, Iowa.*

ZUR OPERATIVEN BEHANDLUNG DER HABITUELLEN SCHULTERLUXATION (The Operative Treatment of Habitual Dislocation of the Shoulder). R. Pfeiffer. *Ztschr. f. orthop. Chir.*, LXIII, 205, 1935.

The author recommends a method which, although it gives good results, is little known. This procedure, published simultaneously by Oudard and Noesske in 1924, has as its basic principle the lengthening of the coronoid process. An incision is made between the deltoid and the pectoralis muscles and the cephalic vein is ligated if necessary. This is followed by the free preparation of the coronoid process, including the biceps, the coracobrachialis, and the pectoralis minor muscles. An oblique subperiosteal tunnel is next chiselled outward and downward, and the external fragment is displaced below about one inch. The periosteum is sutured. If necessary the bones are also sutured through several drill holes. The arm is fixed in abduction for from two to three weeks, after which physical therapy is instituted. Among the twelve cases in which the author operated, there was only one redislocation.—*Joseph Wolf, M.D., Iowa City, Iowa.*

ÜBER EIN SOLITÄRES XANTHOM IM KNOCHEN (Solitary Xanthoma in Bone). Günther Bahls. *Zentralbl. f. Chir.*, LXIII, 1041, May 1936.

From the literature fifty-seven cases of xanthomatosis have been collected by the author. He has divided them into eight groups:

1. Xanthomatosis with skeletal changes, exophthalmos and diabetes insipidus (complete triad of Christian-Rowland disease);
2. Xanthomatosis with skeletal changes and exophthalmos, but without diabetes insipidus (incomplete triad, type A);
3. Xanthomatosis with skeletal changes and diabetes insipidus, but without exophthalmos (incomplete triad, type B).
4. Xanthomatosis with skeletal changes, but without exophthalmos and diabetes insipidus;
5. Xanthomatosis with diabetes insipidus, but without skeletal changes and exophthalmos;
6. Xanthomatosis with growth disturbances;
7. Xanthomatosis or so called xanthosarcomatosis without skeletal changes and diabetes insipidus;
8. Xanthomatosis of the skin in children and in adults.

In addition to these types the author describes a case of a farmer, twenty-six years of age, who injured his right shoulder with an axe while splitting wood. A swelling developed, which was aspirated several times. Eighteen months after the accident operative removal of the swelling was performed. The pathological finding was spindle-cell sarcoma. Three years later a new swelling appeared in the middle third of the right humerus, about four inches below the old swelling. This new swelling was also removed by operation. The pathological slide showed typical xanthoma cells but no sarcoma cells. A careful examination of the whole skeleton showed no other bone lesion.—*Joseph Wolf, M.D., Iowa City, Iowa.*

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